THE HISTORY OF

A LUMP OF GOLD,

From the Mine to the Mint,

BY

ALEXANDER WATT,

Author of "A Lump of Coal," "A Lump of Chalk," "A Lump of Iron," &c., &c.

WITH ILLUSTRATIONS.

"Worth it's weight in Gold."—OLD SAYING.

A. JOHNSTON,

6, PATERNOSTER BUILDINGS, LONDON, E.C.

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PREFACE.

AFTER having written upon Lumps of Coal, Chalk, and Iron, respectively, the Author, in taking A Lump of Gold as the subject for a little history, feels as if he had been a kind of literary butterfly, wandering—not from flower to flower, but from lump to lump—until he alighted upon one most rich in nectar—that is, Gold.

In constructing the work, the Author endeavoured to treat the subject from every point that would be likely to interest the general reader, and at the same time afford useful instruction to the rising members of the community. Although perfection and completeness would not be possible in treating so great a theme in so limited a space, it is hoped that many readers will find in the following pages much information about Gold that is new to them, and which it is desirable that all should possess.

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THE HISTORY

OF

A LUMP OF GOLD.

CHAPTER I.

Introduction.

GOLD! What word in the English language, not Divine, creates so powerful an impression upon the human senses as the sound of this little word! With what silent rapture we receive it as our own! And how different is the feeling when it comes into our hands merely to convey to another—who is to *own* it! Even its presence seems to command respect akin to awe, and admiration beyond the power of utterance. When kindly allowed to inspect the bullion in one of the vaults of the Bank of England recently, how deeply was the mind impressed by the solemn stillness of the place until the courteous guide called our attention to the massive ingots of the precious metal silently reposing upon trucks that might well have felt proud to support such a burthen. It was impossible not to feel that one was in the august presence of the most serviceable mineral substance known on our globe—to the value of about one million and a half sterling. We have melted gold; alloyed it with other metals; refined it; deposited it upon various baser metals by electricity; dissolved it in large quantities for the purposes of

electro-deposition and photography, and in numerous ways have been accustomed to "handle it," but we confess that we have never felt that "contempt" for the metal which is said to be born of "familiarity."*

Gold! Most beautiful of all the metals; most useful of all terrestrial substances; with which any other object under the sun may be obtained in exchange—well did the poet say of thee—

Bright and yellow, hard and cold,
Molten, graven, hammered, and rolled;
Heavy to get and light to hold;
Hoarded, bartered, bought and sold,
Stolen, borrowed, squandered, doled;
Spurned by the young, but hugged by the old
To the very verge of the churchyard mould.

"It is *real gold,*" one will say, when beholding a well-fashioned trinket, without thinking of the toil and skill devoted to its manufacture, as a fool will admire the gilt frame of a picture without noticing the marvellous painting which it envelopes. Apart from the beauty of its colour, as a metal, its great weight, and the many useful and ornamental purposes to which it may be applied, its power of being exchangeable for anything else in the world gives to gold an importance which not even the diamond itself can boast. For good or for evil, it is the most potent substance on the surface of our planet. That it has been productive of as much mischief as benefit to mankind is a question which no one can answer; but that it is capable of doing more good than harm, were it not for the inherent selfishness of human nature, there cannot be the shade of a doubt. While one being will gloat over the amount of gold he owns—and keeps—another revels in its possession for the enjoyment he may derive from its expenditure. The latter is

* Possibly the familiarity has not been carried far enough!

doubtless the happier of the two, while certainly being the most useful to his species.

When we consider the boundless variety of enjoyments—the many sources of happiness—that may be purchased with gold, it seems impossible to conceive that the human mind could voluntarily abandon all these for the solitary and transient enjoyment of accumulating it merely for its own sake, as though the miser would say, with Shakespeare,

"This hand was made to handle nought but gold!"

And yet how many have even deprived themselves of the ordinary comforts of existence to hoard up the precious metal! When we read that certain well-known individuals have accumulated wealth to the extent of many millions sterling—while hideous poverty, suffering, and woe have surrounded them—may we not say that such an accumulation is a crime?

Some persons have argued that gold loses its value so soon as it is transferred into coin. An able writer in *Chambers's Journal,** however, refutes this argument by the following sensible observations:—"Gold is desirable for the sake of its own special virtues, and it becomes additionally valuable when employed as the medium of exchange among nations. It is because of the universal desire of nations to possess it, that it enjoys its supremacy as money. By its comparative indestructibility it commands and enjoys the proud privilege of being the universal standard of value in the world. It is, therefore, elevated, instead of being degraded, by the impress of the Mint stamp; for to its own intrinsic value is added that of being the passport of nations. This is a dignity attained by no other metal. It has been urged that the Government guarantee of a solvent nation stamped upon a piece of tin,

* *Chambers's Journal*, April 5, 1884.

or wood, or paper, will form a counter quite as valuable as gold for a medium of exchange. So it might, but the circulation would only be within certain limits. A Scotch bank-note is passed from hand to hand with even more confidence than a sovereign—in Scotland. But take one to England and observe the difficulty and often impossibility of changing it. The pound-note is worth a sovereign, but its circulating value is local. Even with a Bank of England note, travellers on the Continent occasionally experience some difficulty in effecting a satisfactory exchange. But is there a country in the most rudimentary condition of commerce, where an English sovereign, or a French napoleon, or an American eagle, cannot be at once exchanged at the price of solid gold?"

The amount of gold actually in circulation is estimated to be £100,000,000, but the coinage returns show that the amount of sovereigns and half-sovereigns issued since 1816, when their coinage began, is £247,521,429. "What, then," asks the writer, "has become of the one hundred and forty-seven millions not in circulation?* The coinage returns show that between the years 1864-83, £57,492,842 in sovereigns were coined. A considerable proportion of these have been exported, never to return. The following figures, which I offer with some hesitation, as they may not be rigidly accurate, show that, while during the same period sovereigns were exported and imported, the excess of exports over imports was no less than £25,991,445, or a yearly average of £1,299,572."

* Manufacturing goldsmiths and jewellers could account for some of it.

CHAPTER II.

Early History of Gold.

RESPECTING the antiquity of man's knowledge of gold, we find, on referring to the Holy Scriptures, that so early as in the second chapter of Genesis, ver. 11, Moses states that the land of Havilah, encompassed by one of the four rivers which watered the Garden of Eden, possessed gold; and, moreover, in the following verse he says: "And the gold of that land is good." It is well known that gold, unlike most other metals, chiefly occurs in nature in the metallic state;* and exists, in the form of *gold dust,* in the sands of various rivers and in alluvial soils of certain districts. It is probable, therefore, that the gold referred to by the sacred writer was discovered on the banks of the River Pison, and that it was the first of the metals known to man. That this metal was manufactured into ornaments for personal adornment at a very early period is shown in Genesis xxiv. 22, in which we read, "the man took a golden earring, half a shekel† weight, and two bracelets for her hands, of ten shekels weight of gold." Job mentions gold five times. In chapter xxviii. 1 he says: "Surely there is a vein [or mine] for silver, and a place for gold where they fine it;" and again, referring to the products of the earth, "and it hath dust of gold"—probably the only state in which it was found at that period; and, since it could be separated from earthy matters by the simple process of *washing,* would be readily obtainable.

The Hebrews appear to have designated gold by seven

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* Being a non-oxidizable metal, it could not be subject to chemical change in the earth, like copper, iron, zinc, and other oxidizable metals.

† *Shekel* = 219 grains, troy weight, or nearly half an ounce.

different names:—1. *Zahab*, or gold in general. 2. *Zahab tob*, good gold (as referred to in Genesis). 3. *Zahab Ophir*, gold of Ophir* (1 Kings ix. 28), such as was brought by the navy of Solomon. 4. *Zahab muphaz*, solid gold, pure wrought gold, or "the best gold" (1 Kings x. 18). 5. *Zahab shachut*, beaten gold (2 Chron. ix. 15). 6. *Zahab segor*, shut up gold, that is, gold in the ore, or, as the rabbins explain it, "gold shut up in the treasuries"—gold in bullion. 7. *Zahab parvaim*, or the gold of parvaim, which was employed in building the Temple at Jerusalem, 1015 B.C. An immense quantity of gold must have been used both in the construction of the Temple† and in making the numerous vessels, candlesticks, and utensils required for use or ornamentation; but doubtless at that epoch gold was obtained from the mines of Arabia. In Solomon's time this metal appears to have been exceedingly abundant, and silver probably more so, for this latter metal "was nothing accounted of in the days of Solomon" (1 Kings x. 21). In verse 27 we read, "And the king made silver to be in Jerusalem as stones," and cedars to be as sycamore-trees, "for abundance."

We may form some idea of the vast profusion of gold (and silver) in the days of Solomon from the weight and value of the Jewish coins of the period. A talent of silver = 3000 shekels (a shekel weighing 219 grains) was of the value of about £353. 11*s* 10*d*, and a talent of gold of the same weight was worth £5075 sterling. In one year Solomon is stated to have received (1 Kings x. 14) "six hundred three score and six

* The land of Ophir is supposed to have been on the east coast of Africa, opposite Madagascar—the Gold Coast being on the west.

† It has been estimated that King David accumulated in his lifetime, for building the Temple, gold and silver to the value of not less than 900,000,000 pounds sterling.

talents of gold," or £3,646,350 sterling. From the frequency with which the precious metal is mentioned in the Old Testament, and the many purposes to which it was applied, there can be no doubt that it must have been for a long period exceedingly abundant—far more so indeed than in the mediæval ages, when those remarkable impostors—the early alchemists—wasted their energies in trying to *make* it from baser metals.

That the art of refining gold was practised in the time of Job is clear from the passage before quoted, while David compares the works of the Lord to silver tried in a *furnace* of *earth*, and purified many times. Malachi, again, in comparing the Judge of all the earth to a refiner's fire, says, "And He shall sit as a refiner and purifier of gold and silver: and he shall purify the sons of Levi, and purge them as gold and silver." It does not appear probable that the ancients (except, perhaps, the Egyptians) were acquainted with any other method of refining the precious metals than by the aid of the furnace. Doubtless the mineral acids were unknown to them, therefore the method of *parting* gold and silver with nitric acid, as pursued in our day, could not have been practised. It is believed that nitric acid was unknown until discovered by the alchemists in the thirteenth century; but the author's esteemed friend, the late William Herapath, of Bristol, discovered that the markings on a piece of mummy cloth were made with a solution of silver, which he concluded to have been the *nitrate*, or common marking-ink. It is believed by some persons that the Egyptians were really acquainted both with nitric and sulphuric acids, in which case they would doubtless employ either of them in the operation of separating or *parting* gold and silver, and would therefore be acquainted with the fact that a solution of nitrate of silver would produce a dark and permanent stain upon linen or other similar fabric.

It appears that the art of extracting gold and silver from their ores by the process of *amalgamation* with mercury, or quicksilver, was known at a very early period, for the process is mentioned both by Vitruvius and Pliny, who lived about the beginning of the Christian era, the latter having described the process much in the same way as it is practised in our time. There is little doubt that so soon as mercury was discovered, its power of combining with gold and silver, or *amalgamating* with them, without the aid of heat, would soon be recognized.

The extreme softness and malleability of gold were taken advantage of by Solomon, for in 1 Kings xvi. 17, we read that he made "two hundred targets of beaten gold" and "three hundred shields of beaten gold," but there is no doubt that the Egyptians practised gold-beating at a much earlier period, and were also well-skilled in the art. Indeed, there are evidences in the Egyptian collection of the British Museum of the application of gold-leaf to gilding purposes, and notably in the mummy of a singing boy, the face of which is gilded.

Gold was extensively adopted by the heathens for the figures of their gods or idols, and many of these, according to Herodotus and other writers, were of immense magnitude. The golden calf made by Aaron in the wilderness, from the ear-rings of the male and female Hebrews, was probably of considerable weight.

CHAPTER III.

The Ancient Alchemists—Seeking the Philosopher's Stone—Hermes Trismegistus—Geber—Dr. Salmon—Elias and Dr. Helvetius—Roger Bacon—Basil Valentine—Peter Woulfe.

At that period of scientific history when philosophers recognized but four elements—namely, Earth, Air, Fire, and

Water—it is not to be wondered at that attempts should have been made to transmute some of the products of the earth into the most valuable and beautiful of all metals—Gold. Knowing that most substances changed under the influence of heat, whereby, apparently, new substances were formed, it is not surprising that the early alchemists should really have believed it possible that gold itself could be formed artificially if only the right way of accomplishing so desirable a feat could be hit upon. The *possibility* in these times was never doubted; indeed, we have conversed with chemists of considerable knowledge and ability who have held a similar view; but we were inclined to the belief that in this case, as in many others, "the wish was father to the thought." It is well known that even some of the most enlightened chemists of the seventeenth century believed in the transmutation of the baser metals into gold and silver being *possible*.

Amongst the really gifted men who believed in the *possibility* of transmutation must be numbered the great Lord Bacon, while even Boyle is known to have been sceptical on the subject. It is not so generally known, however, that the greatest philosopher the world has yet known—Sir Isaac Newton—devoted a considerable portion of his time to this pursuit. This startling fact was first made known by Sir David Brewster, in his life of that great philosopher, who has shown that Newton was absorbed in this pursuit for years, and the intense eagerness with which he prosecuted his object is believed, to a great extent, to account for the apparent indifference he showed in so long delaying the publication of his greatest discoveries. When such men as these gave even countenance to the possibility of transmutation, it is not to be wondered at that persons of less natural ability and knowledge should follow the same pursuit and believe in the possibility of its attainment; while, on

the other hand, unscrupulous mountebanks would as surely avail themselves of what little knowledge they could pick up, to impose upon the credulous and ignorant of their time—much in the same spirit as impostors of our own day, who live by their "wits"—upon those who have none.

Hermes Trismegistus.—Of the ancient philosophers, or alchemists, Hermes Trismegistus, who is said to have lived in the year of the world 2076, is supposed to have been the oldest; but many of the writings attributed to him are believed to be—like the gold he professed to produce—spurious. In "The Tractus Aureus, or Golden Work," Hermes is made to apologize for divulging the secrets of the Black Art. "I should never have revealed them," says he, "but for the fear of eternal judgment, or the hazard of the perdition of my soul prevailed with me for such a concealment. It is a debt I am willing to pay to the just, even as the Father of the just liberally bestowed it upon me." From this, one might imagine that the world was going to be enlightened as to the mysteries of alchemy. Not so, however, for they are only to be revealed to the eyes and ears of the sons of art: "not to the profane, the unworthy, and the scoffers, who, being as greedy dogs, wolves, and foxes, are not to feed at our divine repast." The work goes on to explain various matters concerning the *Philosopher's Stone*, by means of which most marvellous things could be done, and then we are directed to "catch the flying bird," which means quicksilver, "and drown it so that it may fly no more;" this is afterwards called the *fixation* of mercury, by uniting it with gold. We now call this *amalgamation*. It is then to be plunged into "the well of the philosophers," or *aqua regia*;* by which its soul

* Or Royal Water, so called because it dissolves the King of Metals—gold.

will be dissipated and its corporeal particles united to the "red eagle"—that is *chloride of gold*, a yellow solution, which becomes blood-red when concentrated.

Geber,* a physician, was also a great alchemist and astrologer, and was believed to have been—unlike most of the same craft—a true philosopher. Like many other of the early alchemists, he appears to have invented some very useful chemical apparatus. He is supposed by some to have possessed the Universal Medicine, for he speaks of curing disease, but Brande thinks this is merely a metaphorical expression relating to transmutation. "Bring me," he says, "the six lepers, that I may cleanse them"—probably meaning the conversion of silver, mercury, copper, iron, tin, and lead into gold—these being the only metals known at that period. Raymond Lully, of Majorca, who was said to be "more ingenious than honest," is reported to have converted iron into gold in the presence of Edward the First, in London, which was coined into rose-nobles.

It was no unusual thing for the alchemists to preface their writings with poetical effusions, many of which are exceedingly amusing. The following stanzas are from the pen of George Ripley, *Chanon of Bridlington, in Yorkshire*, extracted from the preface of his "Compound of Alchemie," dedicated to Edward the Fourth :—

But into chapters thys Treatis I shall devyde,
In number twelve, with dew recapytulatyon;
Superfluous rehearsalls I lay asyde,
Intendyng only to give trew informatyon,
Both of the theoryke and practycall operatyon;
That by my wrytyng who so wyll guyded be,
Of hys intente perfectly speed shall he.

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* Dr. Johnson supposed that the word *gibberish*, anciently written *geberish*, was originally applied to the language of Geber and his tribe.

The fyrst chapter shall be of naturall *Calcination;*
The second of *Dyssolution*, secret and phylosophycall;
The third of our elementall *Separation;*
The fourth of *Conjunction* matrimoniall;
The fyfth of *Putrefaction* then follow shall:
Of *Congelation Albyficative* shall be the sixt,
Then of *Cybation* the seaventh shall follow next.
The secret of our *Sublymation* the eyght shall show;
The nynth shall be of *Fermentatyon;*
The tenth of our *Exaltation* I trow,
The elevent of our mervelose *Multiplycatyon*,
The twelfth of *Projection*, then Recapitulatyon,
And so this treatise shall take an end,
By the help of God, as I intend.

Thus here the Tract of Alchemie doth end;
Which tract was by George Ripley, Chanon, penn'd.

It was composed, writt, and signed his owne
In anno twice seaven hundred seaventy-one.
Reader, assist him, make it thy desire
That after lyfe he may have gentle fire!—Amen.

Dr. Salmon, who lived in the seventeenth century, was also a believer in transmutation; he says: "As to the great philosophic work" (that is, transmutation) "it is my opinion and belief that there is such a thing in nature. I know the matter of fact to be true, though the way and manner of doing it is as yet hid from me. I have been eye-witness that there is a possibility of the transmutation of metals; yet for all these things, will not advise any man, ignorant of the power of nature and the way of operation, to attempt the work, lest, erring in the foundation, he should suffer loss and blame me. Without doubt, it is the gift of God from above; and he that attains to it must patiently wait the moving of the waters; when the destined angel moves the waters of the pool, then is the time to immerge the leprous metal, and cleanse it from all impurities." Van Helmont says: "I am constrained to

believe in the making of gold and silver, though I know many exquisite chemists to have consumed their own and other men's goods in search of this mystery; and to this day we see these worthy and simple labourers cunningly deluded by a diabolical crew of gold and silver sucking flies and leeches. But I know that many will contradict this truth; one says it is the work of the devil, and another that the sauce is dearer than the meat."

The most famous history of the transmutation of metals is that given by Dr. Helvetius, in his "Brief of the Golden Calf: discovering the rarest Miracle in Nature; how by the smallest portion of the Philosopher's Stone, a great Piece of Common Lead was totally transmuted into the purest transplendent Gold, at the Hague, in 1666." The following abridged account of some of the alchemists' proceedings is given by Brande*:—

Elias and Dr. Helvetius.—"The 27th day of December, 1666, in the afternoon, came a stranger to my house at the Hague, in a plebeick habit, of honest gravity and serious authority, of a mean stature and a little long face, black hair not at all curled, a beardless chin, and about forty-four years (as I guess) of age, and born in North Holland. After salutation, he beseeched me, with great reverence, to pardon his rude accesses, for he was a lover of the Pyrotechnian art, and having read my treatise against the sympathic powder of Sir Kenelm Digby, and observed my doubt about the philosophic mystery, induced him to ask me if I really was a disbeliever as to the existence of an universal medicine which would cure all diseases, unless the principal parts were perished, or the predestinated time of death come. I replied, I never met with an adept, or saw such a

* "Manual of Chemistry," by W. T. Brande, F.R.S., &c.

medicine, though I had fervently prayed for it. Then I said, 'Surely you are a learned physician.' 'No,' said he, 'I am a brass-founder, and a lover of chemistry.' He then took from his bosom-pouch a neat ivory box, and out of it three ponderous lumps of stone, each about the bigness of a walnut. I greedily saw and handled for about a quarter of an hour this most noble substance, the value of which might be somewhere about twenty tons of gold; and having drawn from the owner many rare secrets of its admirable effects, I returned him this treasure of treasures with a most sorrowful mind, humbly beseeching him to bestow a fragment of it upon me in perpetual memory of him, though but the size of a coriander seed. 'No, no,' said he, 'that is not lawful, though thou wouldst give me as many golden ducats as would fill this room; for it would have particular consequences, and if fire could be burned of fire, I would at this instant rather cast it all into the fiercest flames.' He then asked if I had a private chamber whose prospect was from the public street; so I presently conducted him to my best furnished room backwards, which he entered, says Helvetius (in the true spirit of Dutch cleanliness), without wiping his shoes, which were full of snow and dirt. I now expected he would bestow some great secret upon me; but in vain. He asked for a piece of gold, and opening his doublet, showed me five pieces of that precious metal which he wore upon a green riband, and which very much excelled mine in flexibility and colour, each being the size of a small trencher. I now earnestly again craved a crumb of the stone, and at last, out of his philosophical commiseration, he gave me a morsel as large as a rape-seed. 'But,' I said, 'this scanty portion will scarcely transmute four grains of lead.' 'Then,' said he, 'deliver it me back,' which I did, in hopes of getting a greater parcel; but he, cutting off half with his nail, said, 'even this is sufficient for

thee.' 'Sir,' said I, with a dejected countenance, 'What means this?' And he said, 'Even that will transmute half an ounce of lead.' So I gave him great thanks, and said I would try it, and reveal it to no one. He then took his leave, and said he would call again the next morning at nine. I then confessed that, while the mass of his medicine was in my hand the day before, I had secretly scraped off a bit with my nail, which I projected on lead, but it caused no transmutation, for the whole flew away in fumes. 'Friend,' said he, 'thou art more dexterous in committing theft than in applying medicine; hadst thou wrapt up thy stolen prey in yellow wax, it would have penetrated and transmuted the lead into gold.' I then asked if the philosophic work cost much or required long time, for philosophers say that nine or ten months are required for it. He answered, 'Their writings are only to be understood by adepts, without whom no student can prepare this magistery. Fling not away, therefore, thy money and goods in hunting out this art, for thou shalt never find it.' To which I replied, 'As thy master showed it thee, so mayest thou perchance discover something thereof to me, who know the rudiments, and therefore it may be easier to add to a foundation than begin anew.' 'In this art,' said he, 'it is quite otherwise; for unless thou knowest the thing from head to heel, thou canst not break open the glassy seal of Hermes. But enough; to-morrow, at the ninth hour, I will show thee the manner of projection.' But Elias never came again; so my wife, who was curious in the art whereof the worthy man had discoursed, teazed me to make the experiment with the little spark of bounty the artist had left me; so I melted half an ounce of lead, upon which my wife put in the said medicine; it hissed and bubbled, and in a quarter of an hour the mass of lead was transmuted into fine gold, at which we were exceedingly amazed. I took it to the

goldsmith, who judged it most excellent, and willingly offered fifty florins for each ounce." Such is the celebrated history of Elias the artist, and Dr. Helvetius.

Roger Bacon.—Among the really great alchemists must be mentioned Roger Bacon—otherwise Friar Bacon—a monk of the Franciscan order, who lived in the thirteenth century, and was an ancestor of the great Lord Bacon. His "Opus Majus, or Alchymia Major," considering the period in which it was written, is both perspicuous and comprehensive. In attempting to expose the ignorance of the University teaching at Oxford, in 1240, he jeopardized his personal liberty; being accused of practising witchcraft, he was thrown into prison, and nearly starved, for exposing the immorality of the clergy; and, according to some authorities, stood a chance of being burnt as a magician. According to Gmelin, Roger Bacon wrote no less than eighteen chemical works.

Basil Valentine.—Another remarkable alchemist was Basil Valentine, who wrote in the middle of the fifteenth century, one of his most notable works being "The Triumphal Chariot of Antimony." He appears to have had a profound contempt for those physicians who differed from him, and were unable to prepare their own medicines, as will be seen from the following passage:—"They know not whether they be hot or cold; moist or dry; black or white; they only know them as written in their books, and seek after nothing but money. Labour is tedious to them, and they commit all to chance; they have no conscience, and coals are outlandish wares with them; they write long scrolls of prescriptions, and the apothecary thumps their medicine in his mortar, and health out of his patient." To this remarkable man we are indebted for the discovery of two of the most important acids employed in the chemical arts, namely, nitric acid and sulphuric acid, or oil of vitriol.

Peter Woulfe.—Probably the last true believer in the mysteries of the art of alchemy was Peter Woulfe, who occupied chambers in Barnard's Inn, Holborn, during the latter part of the last century and the beginning of the present. Brande says: "His rooms, which were extensive, were so filled with furnaces and apparatus, that it was difficult to reach his fireside. Dr. Babington told me that he once put down his hat and never could find it again, such was the confusion of boxes and parcels that lay about the chamber. His breakfast hour was four in the morning; a few of his select friends were occasionally invited to this repast, to whom a secret signal was given, by which they gained entrance, knocking a certain number of times at the inner door of the apartment. He had long vainly searched for the elixir, and attributed his repeated failures to the want of due preparation by pious and charitable acts. I understand that some of his apparatus is still extant, upon which are supplications for success, and for the welfare of the adepts." Some of the apparatus designed by Peter Woulfe is used not only in the laboratory, but in chemical manufactures, to this day; and several pieces of his original apparatus, including an *athanor*, or self-supplying furnace, are in the laboratory of the Royal Institution.

CHAPTER IV.

Mineralogy of Gold—Principal Sources of Gold—Discovery of Gold in California—Discovery of Gold in Australia—The World's Gold Production.

Gold is found in nature only in the metallic state, and generally in the form of dust, or in small spangles, but is occasionally found in *nuggets* of considerable size. It also

occurs in threads of various dimensions, twisted and interlaced into a chain of octahedral crystals. Sometimes this metal has been found in crystals of the form shown in fig. 1.

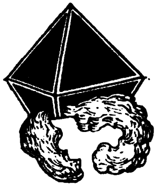


Fig. 1.

With the exception of iron, gold is the most widely diffused of all metals, but it mostly occurs in such minute quantities as either to escape observation, or not to repay the cost of extracting it. That it must have been obtained in enormous quantities in the earlier part of the world's history is clearly proved by the scriptural writings, and it is equally probable that at no period since has this pre-eminently important metal been obtained in such abundance as since the period of the great discoveries of gold in California and Australia in the years 1847 and 1851.

The mineral formations in which gold occurs—and which may be considered Nature's principal storehouses for the precious metal—are the crystalline primitive rocks, the compact transition rocks, the trachytic and trap rocks, and alluvial soils.

Principal Sources of Gold.—In ancient times, Spain possessed mines of gold in regular veins, and the Tagus and other rivers of that country were said to "roll over golden sands." France has not yielded any workable gold mines, but the sands of some of its rivers are auriferous. In the County of Wicklow, in Ireland, a quartzose and ferruginous sand occurs round the coast, in which many particles of gold, as also small nuggets, were discovered in the latter part of the last century, one of which weighed twenty ounces. About one thousand ounces were obtained, but after awhile the search was abandoned, owing, probably, to the absence of practical knowledge in the peasants who had been engaged in the operation. When in Ireland many years ago, the author made several excursions to the rocky coast of Wicklow, whence the gold referred to had

been procured, and from the character of the disintegrated matter upon the beach (which is an exceedingly coarse sand, or "free stone," as it is called in Dublin), he entertained the opinion, as indeed he does at the present time, that beneath this sand there is probably a considerable quantity of gold.

Mr. J. Calvert, in his "Gold Rocks of Great Britain and Ireland," gives the following weights of gold nuggets obtained from Wicklow—namely, four, five, six, seven, nine, eighteen, twenty-two, and forty ounces. The abundance of gold ornaments and weapons found in Ireland, and which are so peculiar to the people, clearly show that considerable quantities of gold must have been obtained at an early period in their history. Sufficient evidence of this is given in the testimonies of the ancient Irish writers. Delarnes, in his "History of Caen," states that after the Norman conquest of the British Islands, treasure was exacted from both to the exchequer of Normandy, the tribute exacted from England being 23,730 marcs of silver, while from Ireland four hundred marcs of silver and four hundred ounces of gold—an enormous quantity for those times was exacted.

The chief sources from which gold is obtained are the alluvial (that is *water-worn*) deposits, consisting of sand and gravel, formed by the disintegration of quartz, granite, and other volcanic rocks. In these alluvial beds gold is always found in the metallic state, not quite pure, but generally combined with silver, copper, and small quantities of other metals, including iron. It is, however, obtained from mines, as in Hungary and Transylvania, Sweden, Asia, the Ural Mountains in Siberia, &c.

The principal gold workings known at the present day are those of Australia, California, Mexico, and the Appalachian Mountains in North America; Brazil, Peru, and Chili, in South

America; Kordofan, between Darfur and Abyssinia, and the Gold Coast, in Africa; the Ural Mountains and Hungary.

Discovery of Gold in California.—There is no epoch in the modern history of gold so important as that which includes the discovery and working of the gold-fields of California and Australia. It was on the property of an intelligent Swiss settler, Captain Suter, that the first traces of gold were discovered in California, in September, 1847. The accident which revealed the golden treasures of this part of the American Continent are thus related by a writer in *The Quarterly Review* for September, 1852:—"Captain Suter, the first white man who had established himself in the district where the Americanos joins the Sacramento, having erected a saw-mill on the former river, whose tail-end turned out to be too narrow, took out the wheel, and let the water run freely off. A great body of earth having been carried away by the torrent, laid bare many shining spangles, and on examination Mr. Marshall, his surveyor, picked up several little lumps of gold. He and Captain Suter then commenced a search together, and gathered an ounce of the ore from the sand without any difficulty, and with his knife the Captain picked out a lump of an ounce and a half from the rock. A Kentucky workman employed at the mill espied their supposed secret discovery, and when, after a short absence, the gentlemen returned, he showed them a handful of glittering dust. The Captain hired a gang of fifty Indians, and set them to work. The news spread, but the announcement of the discovery was received with incredulity beyond the immediate neighbourhood. But presently, when large and continuous imports of gold from San Francisco placed the matter beyond doubt, there ensued such a stir in the States as even in that go-ahead region is wholly without parallel—numbers of every age, and of every variety of

occupation, pushed for the land of promise. Many were accompanied by their families, and most, under the excitement of the hour, overlooked their physical fitness, and their inability to procure necessaries. The waters of the Humboldt, from their head to their 'sink'—a space of nearly three hundred miles—are, in the dry season, strongly impregnated with alkali, and it was here they first began to faint. Some died from thirst, others from ague, others fell beneath the burthens they attempted to carry, when their last animal dropped into the putrid marsh, which grew thicker at every step. Beyond the 'sink' the diminished bands had to encounter sixty or seventy miles of desert, where not a blade of herbage grew, and not a drop of pure water could be procured; and those who pushed safely through the ordeal had still to ascend the icy slopes of Sierra Nevada, where the rigours of winter were added to all other difficulties. At different points, one being almost in sight of the Golden Land, overwearied groups had formed an encampment, in case, perhaps, some help might reach them. It is to the credit of the settlers that, hearing of this, they strained their resources to the utmost to afford relief. Yet when all was done, a sick, destitute, and most wretched horde of stragglers was all that remained of the multitude who, full of hope and spirits, had commenced the prairie journey."

Some idea of the richness of the Californian soil may be formed from the following. At a spot which was appropriately named Mount Ophir, the auriferous soil is described as soft clay and slates, saturated with gold in small particles and large lumps.* This was found from ten to thirty feet below the

* That is, as compared with the greater quantity of the metal, which is in fine particles. Nuggets of great size are not reported to have been found in California.

surface; and even Mexicans who made the discovery, and kept their secret for eight days, made in that short time 217,000 dollars. Others, from a shaft twenty feet deep, obtained a soft clayey soil, which they raised in buckets, and found from eight to twelve dollars' worth of gold in each bucket. The total produce from this region down to the end of 1855, or about eight years from the time of Captain Suter's discovery, has been estimated at £64,000,000 sterling; and since that period the annual gold produce of this district averaged about £14,000,000 sterling.

Discovery of Gold in Australia.—It is remarkable that within a period of four years two such prolific sources of gold as those of California and Australia should have been discovered. While Captain Suter's accidental discovery of gold in the former locality is accepted as the true story of its first extraction from Californian soil, there have been many claimants for the honour of discovering the precious metal in Australia; but there is no doubt that to Sir Roderick Murchison is due the credit of being the first to suggest that gold might probably be found in Australia long before its actual existence became known. He thus states the facts:—

"Having in the year 1844 recently returned from the auriferous Ural Mountains, and had the advantage of examining the numerous specimens collected by my friend Count Strazelecki along the eastern chain of Australia, seeing the great similarity of the rocks of those two distant countries, I could have little difficulty in drawing a parallel between them: in doing which I was naturally struck by the circumstance that no gold had *yet* been found in the Australian range, which I termed in anticipation the 'Corderilla,' impressed with the conviction that gold would, sooner or later, be found in the British Colony. I learnt, in 1846, with satisfaction that a

specimen of the ore had been discovered. I therefore encouraged the unemployed miners of Cornwall to emigrate, and dig for gold as they dug for tin in the gravel of their own district. These notices were, as far as I know, the first printed documents relating to Australian gold."

The actual discovery of the gold-fields of Australia is attributed to a gentleman named Hargreaves, who, having returned from California, occupied himself for two months in exploring a considerable tract of country in Australia. On the 3rd of April, 1851, he wrote to the Colonial Secretary, offering to point out to the officials the localities in which he had discovered gold, for the sum of £500; but subsequently he agreed to trust to the liberality of the Colonial Government, and on the 13th of April he named the localities from which he had obtained specimens of the precions metal—about 150 miles west of Sydney. Some persons who had been employed by Mr. Hargreaves, however, divulged the fact that on the 8th of May several ounces of gold had been found by them at Summer Creek; and on the 13th of the same month great excitement was caused by the report that a solid lump, weighing thirteen ounces, had been found. From that time hundreds of persons left their occupations, and flocked to the "diggings."

The official announcement of the discovery of the Australian gold-fields, was made in Great Britain by a dispatch from Sir C. A. Fitzroy to Earl Grey, on September 18th, 1851, many persons, each provided with a tin dish, having obtained from one to two ounces of gold per day. On May the 28th, 1852, he wrote that lumps of gold had been found, weighing from one to four pounds; and on the following day that gold was found in abundance, and people of every class were flocking to the locality; that the field was rich, and from the geological formation of the country, of immense area. The gold was

found, by assay, to consist of fine gold, 91·1; silver, 8·333, with a trace of base metal. It was, in fact, 22-carat gold, or of the same standard as our gold current coin. On the 17th of July, a mass of gold, weighing 106 lb., was discovered imbedded in a matrix of quartz, about fifty-three miles from Bathurst; besides this splendid treasure, considerable quantities of gold were obtained from various parts of the same range. A party of six persons secured £400 worth in ten days by means of a quicksilver machine; and another party of three, who had been unsuccessful for seven days, obtained in five days afterwards more than 200 ounces. In August, 1851, Lieut.-Governor Latroche announced to Earl Grey, from Melbourne, the discovery of large deposits of gold in that district. In a second Parliamentary Blue Book (February, 1852), it is stated that 79,340 ounces of gold, worth £257,855. 7*s*, had been previously forwarded to England; and that the gold-fields of Victoria rivalled, if they did not excel, those of New South Wales. A short time after, the product equalled about £5,000,000 sterling.

On the 15th of June, 1858, a party of twenty-four, at Bakery Hill, Ballarat, Victoria, working at a depth of 180 ft., alighted upon a nugget, of no regular shape, it is true, but its length was twenty inches, breadth twelve inches, and depth seven inches; while its gross weight was 184 lb. 9 oz. 16 dwt., or 2217 oz. 16 dwt., troy weight. This noble specimen of what a nugget ought to be—the author's ideal of a lump of gold!—received the name of the "Welcome" nugget, a model of which, by the late Professor Tennant, may be seen in the Natural History Collection, South Kensington. It was first sold at Ballarat, in 1858, for £10,500, and, after being exhibited in Melbourne, was sold there, on March 18th, 1859 (when it weighed 2195 oz.), for £9325, or at the rate of £4. 4*s* 11*d* per

ounce. When melted in London, in November, 1859, and assayed, it proved to contain 99·20 per cent. of gold, or 23 carats 3⅛ gr. fine.

The next remarkable nugget was discovered on the 5th of February, 1869, near Dunolly, Victoria, by John Deason and Richard Oates.* Its weight was 2280 oz. 10 dwt. 14 grs. It was found on the extreme margin of a patch of auriferous alluvium trending from Bulldog Reef, lying within two feet of the bed of the bed-rock (sandstone), in loose gravelly loam, resting on stiff red clay, barely covered with earth. It was about twenty-one inches long and about ten inches in thickness, and though mixed with quartz, the great body of it was solid gold. This splendid nugget received the name of the "Welcome Stranger," and a model of it may be seen by the side of its rival model, "Welcome," in the Natural History Collection.

Mr. Brough Smyth says: "It is to be regretted that a cast or photograph was not made, and the weight and specific gravity of it ascertained when it was first dug out of the ground. The discoverers appear to have heated it in the fire of their hut, in order to get rid of the quartz, and thus reduce its weight before conveying it to the bank at Dunolly. The melted gold from it was 2268 oz. 10 dwt. 14 gr.; but a number of specimens and pieces of gold (weighing more than 1 lb.) were detached from it before it got into the hands of the bank managers, and what was broken off in the hut whilst it was in the fire it is useless to guess."

After being *thinned down* in this way, its value at the Bank of England was £9534. The "Welcome Stranger" is believed to have been the largest nugget of gold ever found. The

* "Gold Fields and Mineral Districts of Victoria." By R. Brough Smyth.

district in which it was found is famous for nuggets of considerable size, and Mr. Smyth thinks it probable "that other pieces of gold will be found as far exceeding the 'Welcome Stranger' in weight and value as that nugget exceeds any yet recorded." Near the spot where this lump of gold was found were unearthed two nuggets, weighing respectively 114 oz. and 36 oz.

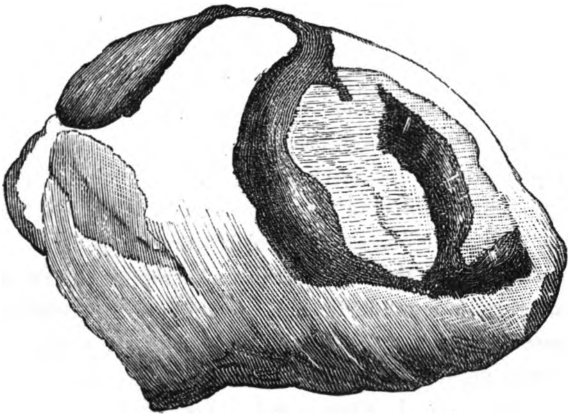


Fig. 2.

The drawing (fig. 2) represents the first gold nugget received from Australia in 1851. Soon after the discoveries of gold in Australia were made known in that year, followed by reports of the richness of the gold-fields and the great success of the diggers, the excitement in England was intense. Thousands of persons—many of whom were glad of *any* excuse to emigrate—turned their attention to "the diggings," and with hasty preparation took ship and floated away to the Land of Promise. So great was the "rush" for a time that the difficulty of securing a berth in an outward-bound vessel was experienced by many. Indeed, if the "diggings" had been nearer home instead of

sixteen thousand miles away, the exodus from England alone would have been incredible. Nor was the rush to the "diggings" confined to the dwellers in Great Britain, for persons of all nationalities, inoculated by the "gold fever," as it was called, sought the Australian gold-fields to make their fortune—if possible.

The produce of gold in Australia and California far outshone that of all other countries in the world—in modern times. Previous to the year 1847, the annual production of gold did not amount to £5,000,000 sterling, whereas it has since exceeded £30,000,000.

The World's Gold Production.—The statisticians of the United States Mint estimate that the total production of gold in the world during the four hundred years ending in 1882 was ten thousand three hundred and ninety-four tons, equal in value to £1,716,463,795. On the basis of the last three years, the average annual production of gold in the world is now twenty-one and a half millions sterling. Taking 1881 as an illustration, the largest contributors were—

United States	£6,940,000
Australasia	6,225,000
Russia	5,710,200
Mexico	197,000
Germany	48,200
Chili	25,754
Colombia	800,000
Austria	248,000
Venezuela	455,000
Canada	219,000

CHAPTER V.

Metallurgy of Gold—Mechanical Treatment of Gold Ore—Crushing—Stamping—Grinding—Washing—Amalgamation of the Ores of Gold—Melting the Gold.

The gold found in auriferous soils, or in the sand of rivers, is generally separated by *washing* and *amalgamation*. By the first operation the larger particles of gold are separated from the earthy matters by washing the sands upon inclined tables or planks, sometimes covered by a cloth, and then by hand in wooden bowls. Quicksilver is employed to *amalgamate* the finer particles, and this is afterwards recovered by distillation. The Bohemians and others who wash the auriferous sands of Hungary, use a plank with twenty-four grooves cut in its surface. The plank is held in an inclined position, and the sand being placed in the first groove, water is thrown upon it, when the gold, mixed with a little sand, collects towards the lowest groove. This mixture of gold and sand is then placed in a flat wooden bowl, and by a peculiar motion of the hand the sand is caused to separate entirely from the gold.

The stony ores are first ground by hand, or by a stamping mill, and then washed in hand bowls, or on wooden tables or planks. The auriferous *sulphurets*, as the sulphurets of copper, silver, arsenic, and iron, are much poorer in metal—some containing only one 200,000th part of gold; but even this small proportion can, with careful treatment, be extracted with profit. The gold in these ores is separated by two different processes, namely, by *fusion* and *amalgamation*. The ore is first *roasted* or calcined, by which the sulphur is driven off; it is then

melted into *mattes*, which are again roasted and next fused with lead, whereby an auriferous lead is obtained, which may be refined by *cupellation*.

When the ores are very rich in gold, they are melted directly with lead, without being calcined. These processes, however, are not practised where quicksilver is obtainable, owing to the superior economy and effectiveness of the process of amalgamation.

Mechanical Treatment of Gold Ore.—Although the greatest amount of gold is obtained by the direct washing of auriferous sand and alluvial soils, still a very considerable proportion is extracted from solid quartz rocks. In the progress of time, volcanic rocks have been partially disintegrated and converted into sand by the action of the atmosphere and moisture, by which particles of gold of greater or lesser size have been liberated and become mingled with the disintegrated matter or sand. The solid rocks, however, are successfully explored by mining companies for the precious metal and yield considerable quantities of gold. To extract the metal from this source, however, the dislodged fragments of rock require to be subjected to certain operations of *crushing*, *stamping*, and *grinding*, to separate the gold from its *gangue* or earthy matter, previous to its final extraction by chemical or metallurgical processes.

Crushing.—This is sometimes effected by means of powerful cylindrical rollers of cast iron, moving in opposite directions, by which the ore becomes reduced to small fragments, which, when necessary, are brought to a finer state of division by *stamping*.

Stamping.—This is effected in a kind of mill formed of a series of wooden pestles with iron heads, set in motion either by steam or water power. These pestles are placed in a row,

and each one is successively raised by a mechanical contrivance, and then falls upon the crushed ore beneath, the repeated blows thus given having the effect of pulverizing the crude material and reducing it to a coarse powder. The pestles generally weigh from three hundred to four hundred pounds each, and are sometimes made wholly of iron. The ore to be stamped is placed in a large wooden trough beneath, in which are openings provided with perforated sheet-iron strainers. The pulverized ore is carried through these strainers by a stream of water passing through the trough, and passes over an inclined table, kept in motion by a chain connected with the machinery. The heavier and richer portions of the ore accumulate on this table, while the lighter particles are washed away into reservoirs, in which they subside according to their *gravity*.

Grinding.—When it is necessary to reduce the ore to a still greater degree of fineness grinding-mills are employed. In Mexico, the "sands" resulting from the operation of stamping are ground in water by a machine resembling an ordinary mill-stone, but the mills should either be of cast iron or fine granite.

Washing.—In the "diggings," where the precious metal has to be sought and separated from earthy matter already reduced to a more or less pulverulent (powdery) state by nature, the washing process is the first and frequently the only method by which gold is obtained, either in the form of dust or nuggets. There must, however, be a considerable loss of gold in a finely divided state when this method only is adopted, which could be easily secured if it were practicable always to employ mercury to extract the invisible particles of the precious metal. In Australia and California a machine called the *cradle*, or rocking-machine, is much employed for washing auriferous sand or earthy matter. This consists of a wooden trough six or seven feet long, beneath which are two *rockers*, as in the ordinary

child's cradle; this machine either rests on the ground, or is suspended by ropes from a cross-bar supported by two uprights. The cradle in either case is slightly inclined towards one end, to allow the water to run off, and at the opposite end is placed a sieve or grating on which the material to be washed is deposited; the interior of the bottom of the trough is furnished with several transverse bars to check the heavier particles in their descent, while the lighter earthy matters and water flow off. To work this apparatus four men are required—one to dig the auriferous sand, a second to convey it to the cradle and place it on the grating, a third to rock the trough, and the fourth to keep up the supply of water and superintend the proper washing of the material. In Brazil, the excavations and washings of river sand are conducted by negroes, who are supplied with large wooden bowls, about two feet in diameter, and one foot deep, and also a leather bag, fastened before them, into which the particles of gold dust are collected, after repeated washings. The greater portion of the gold of commerce is imported in the form of "gold dust," or small grains, extracted from auriferous soils by the simple process of washing, and is afterwards still further purified from earthy matter by repeated washings; or the metal is extracted by amalgamation with quicksilver.

Amalgamation of the Ores of Gold.—The mode of extracting gold by mercury in South America is as follows:—A grinding-mill, consisting of a heavy circular stone, revolving in a stone trough, is employed, and into the trough, which is circular, quartz broken to the size of walnuts is placed, and several pounds of mercury are then poured in; a small stream of water trickles into the trough, and flows over a particular spot, carrying with it the finer ground particles of earthy matter. At the depth of a foot it flows into a goatskin bag, having some quicksilver in it, and thence to a second, third, and even to a fifth

bag, so long as any fall is obtained. After working several hours, the mill is stopped, and all the quicksilver collected in a long narrow linen bag; this bag is then squeezed till all the uncombined mercury passes through, and only the amalgam of gold remains behind. The amalgam is then placed on a piece of iron, strongly heated, and resting on a brick standing in water; an earthen cupola or douce is then placed over the whole, forming a water-joint at the bottom, while the neck of the cupola dips into a vessel of water. The heat of the iron expels the mercury from the amalgam, and it condenses in the water, from which it is afterwards collected for further use. A spongy mass of *fine gold* remains upon the iron plate.

In Piedmont, where auriferous pyrites have been worked from a very remote antiquity, the gold is extracted almost entirely by amalgamation. The amalgamating-mills are erected in great numbers on the banks of the various rivulets which traverse the mountains. These establishments usually consist of small wooden buildings, each of which contains four amalgamating machines. In the valley of Anzasca there are upwards of two hundred mills procuring a remunerative return from very poor soil by amalgamation. After grinding or triturating in a mill resembling the ordinary pug-mill, driven by water power, the powder is carried off by a stream of water to the amalgamating mills. The powder, while suspended in the water, is conducted to the upper mill by a spout, and from this to a second mill, also by a spout, and so on through a series of mills. Each mill consists of a cast-iron basin, fastened by screws to the top of a strong frame or table, and fitted in its centre with a tubular opening traversed by an axis set in motion by a toothed wheel, with which revolves a wooden muller, fixed to an upright spindle. The rotating muller is made of hard wood, and is hollowed out like a funnel, in which the auriferous slime or

schlich accumulates, and gradually penetrates into a space between its external surface and the bottom or interior surface of the iron basin; from this it flows to the next mill by a spout. In the bottom of the fixed vessel about half a hundredweight of mercury is placed, which lies to the depth of about half an inch, and when the machine is in motion, the pounded mineral is constantly agitated and mixed with the liquid metal. The minute particles of gold are there seized by the mercury, and become dissolved by it, while those which escape amalgamation in the first mill are retained by the second, third, and so on through the series. The mills are worked in this way for several weeks, or until the mercury becomes sufficiently charged with gold, when they are stopped, and the amalgam removed and strained through chamois leather to separate the excess of mercury from the amalgam, which usually contains about one-third its weight of pure gold. The mercury is afterwards recovered by distillation in an iron retort, the beak of which dips into water. About twenty shillings' worth of gold are obtained from each 150 lb. of mineral.—*Muspratt.*

In extracting gold by amalgamation, various forms of apparatus are employed, but the principle of the process will doubtless be sufficiently understood by the examples we have given. We may, however, state that during the great gold mania in 1853, Mr. Burdon, of New York, contrived a very useful machine—well known as Burdon's gold ore pulverizor and amalgamator—which proved very effective at a time when it was really needed.

The gold which is obtained by the process of amalgamation generally contains silver, copper, and other metals in varying proportion, according to the source from which it is derived.

When we bear in mind the feverish haste with which gold was sought and obtained by the inexperienced host—of all nationalities—that flocked to the "diggings" during the gold

fever of 1852-3, we may venture to opine, since the metal was obtained solely by *washing*—except when nuggets of the "Welcome Stranger" type turned up—that the abandoned sludge of these workings would be profitable ground for careful and industrious workers of the amalgamation process. Indeed, it is quite within the radius of probability that many of the inexpert diggers threw away—by clumsiness of manipulation—more gold than they carried away. Indeed, it is known that ore in Hungary containing only three ounces of gold and silver in fifty tons could be worked at a profit, although it had to be obtained from the solid rocks at depths of 200 fathoms, and had to be subjected to the processes of crushing and stamping.

Melting the Gold.—The gold obtained by the process of amalgamation, or the gold dust received from the gold worker, is first melted in a crucible with dried borax and then cast into ingots, by which it becomes separated from earthy matters, and at the same time assumes a convenient shape for further treatment in the refining process. The crucible, which is commonly made of plumbago (blacklead), is first heated in an ordinary melting furnace; the gold and dried borax are then introduced and the heat kept up until the gold is melted, when the slag, which consists of the coarser impurities, accumulates on the surface, and is then skimmed off. The metal is next poured into ingot moulds, previously warmed and greased, by which it becomes cast into bars or ingots.

CHAPTER VI.

Assaying Gold—Apparatus and Materials used in Assaying —The Assay Process—Cupellation—Parting—Assay of Gold Bullion—Quartation—Liquation.

THE art of *assaying* gold consists in determining the quantity, or proportion, of gold in native ores, coin, bullion, or alloys of gold, in the *dry way*, or by *cupellation*. It differs from *chemical analysis*, inasmuch as an assay merely determines the quantity of the precious metal (gold or silver) in the sample examined, regardless of any other constituents which may be present; in chemical analysis, the proportions of all or any of the ingredients may be ascertained at the will of the analyst. It is supposed that a crude system of assaying began to be practised in England soon after the Roman conquest, but its origin, as an art, is generally attributed to the Bishop of Salisbury, who was treasurer to Henry I., in the early part of the 12th century. During the reign of Edward III. (A.D. 1354) assay was formally established in this country, and was subsequently regulated by several Acts of Parliament in the reigns of William III., 1700, and Anne, 1705, &c. Assay masters were appointed at Sheffield and Birmingham (A.D. 1773). The assay master of the Royal Mint of England was formally appointed, with other members of the Corporation, under charter of Edward I. (A.D. 1278). According to Stowe, the Mint at this time was kept by Italians, the English being ignorant of the art of coinage and assay.

The Apparatus and Materials used in Assaying consist of an assay furnace; a *muffle;* a series of bone-ash *cupels;* and tongs. Besides these, *an assay balance* of great delicacy and appropriate weights are employed.

Without going very deeply into the operations of assaying, we will endeavour, as briefly as possible, to describe the general system adopted, but before doing so it will be necessary to explain the construction of the assay furnace. The furnace employed at the Royal Mint, and also at Goldsmiths' Hall, London, has the following construction:—*a a* (fig. 3) are rollers, on which the furnace rests; *b* is the ash-pit; *c*, one of the ash-pit *dampers*, for regulating the draught; *d*, the grate supporting the *muffle plate*; *e*, the muffle containing a series of cupels; *f*, the mouth-plate, upon which, during use, is piled ignited pieces of charcoal, by which the mouth of the furnace is closed, and heated air made to pass over the cupels; *h*, interior of the furnace containing charcoal; *i i*, walls of the furnace; *k*, movable chimney, for regulating the draught. The height of the furnace is $2\frac{1}{2}$ feet.

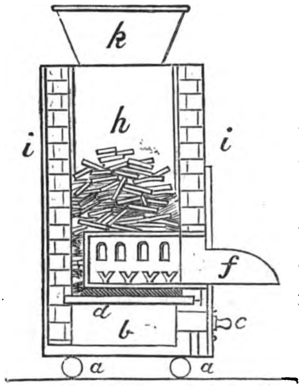


Fig. 3.

The *Muffle* (fig. 4) is a chamber made of clay, open at one end to admit the cupels; and the sides and top are perforated, as in the engraving.

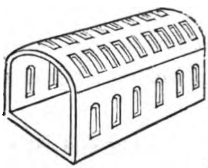


Fig. 4.

Fig. 5.

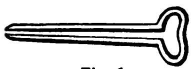


Fig. 6.

The *Cupel* (fig. 5) is a small, porous shallow *crucible*,

generally made of *bone-ash* (*phosphate of lime*) or *calcined horn.* In making the cupels the powdered ash, slightly moistened with water, is placed in a circular steel mould, and after being pressed down tight, is shaped with a rammer having a convex face of polished steel, which is struck with great force with a mallet until the mass becomes sufficiently hard. The cupels, as soon as they are made, are placed aside for several weeks to dry. The cupels weigh from 180 to 200 grains each; those used at the Mint are made from the calcined cores of ox horns. The *tongs* (fig. 6) are employed for introducing the *lead* used in the process of cupellation.

Cupellation.—The *principle* involved in cupellation may be thus explained:—Gold and silver have a very slight affinity for oxygen as compared with copper, tin, and other inferior metals, and the tendency which these latter metals have to *oxidize* or absorb oxygen gas rapidly in contact with lead at a high temperature causes them to sink, with the lead, into any porous vessel (such as a bone-ash cupel) in a thin, glassy, or *vitreous* state. The *conditions* essential to the success of the process—and which are found in the precious metals—are: "that the metal from which we wish to part the oxides *must not be volatile;*" and "that it should also melt and form a *button* at the heat of cupellation, for otherwise it would continue disseminated, attached to the portion of oxide spread over the cupel, and incapable of being collected."

The Assay Process.—The muffle, with the cupels properly arranged, is placed in the furnace, and the charcoal added and lighted at the top by means of a few red-hot pieces thrown in at last. When the cupels have been exposed for about half an hour, and have acquired a *white heat,* the proportion of lead*

* Sixteen parts of lead are generally used to "sweat out" one part of copper.

required for the particular assay is put into the crucible by means of the tongs (fig. 6). When this has become bright red, and *circulates*, as it is called, the sample for assay (which weighs twelve grains, and is called the "assay pound") wrapped in a small piece of paper, or lead-foil, is put into the cupel. The fire is then kept up strongly until the metal enters the lead and *circulates* well, when the heat, slightly diminished, is so regulated that the assay appears *convex*, and more glowing than the cupel itself, whilst the *undulations* circulate in all directions, and the middle of the metal appears smooth, with a margin of litharge (oxide of lead) which is freely absorbed by the cupel. When the metal becomes bright and shining, or begins to *lighten*, as it is termed, and prismatic colours (like the rainbow) suddenly flash across the globules, and undulate and cross each other, followed by the metal becoming very brilliant and clear, and at length fixed and solid (termed *brightening*), the separation is ended, and the process complete. The cupels are then drawn to the mouth of the muffle, and allowed to cool slowly. When cold, the resulting button is removed, and is then subjected to the operations of *quartation, parting,* and *annealing* before being weighed.

The lead added to the gold or silver to be assayed serves chiefly to dissolve the oxidized copper. The cupels (being porous) allow the fused oxides to flow through them as though through a fine sieve, but are impermeable to the particles of metals; thus the former pass readily through the substance of the cupels, while the latter remain upon their surface. Again, while the fused metal will preserve a hemispherical shape in the cupels, as a globule of quicksilver does in a wine glass, the fused oxide spreads over the surface of the cupels and penetrates their substance like a liquid. If, therefore, we put into a cupel two metals, one of which is

oxidizable and the other not so, and subject them to sufficient heat, the latter will remain in the hollow of the cupel as a molten bead or button, while the other will be absorbed by the cupel, being, as it were, *filtered* from the unoxidizable metal.

In estimating or expressing the fineness of gold, the entire mass spoken of is supposed to weigh twenty-four carats of twelve grains each, either real or merely proportional, like the assayer's weights, and the pure gold is called *fine*. For instance, if gold be said to be twenty-three carats fine, it is understood that in a mass weighing twenty-four carats the quantity of pure gold amounts to twenty-three carats.

Parting.—This term is applied to a method of separating gold from silver, and is based upon the fact that silver is readily dissolved by nitric acid, while gold is absolutely insoluble in that fluid. If the proportion of gold to that of silver be greater than one to two, then the particles of the superior metal so protect or envelop the silver that even boiling nitric acid has no effect whatever upon the alloy. It is therefore necessary, for the purposes of *parting*, that the proportion of silver should be at least double that of the gold.

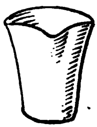
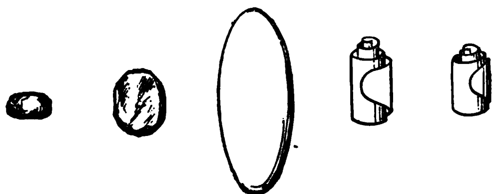


Fig. 7.

Fig. 8.



a b c d e

Fig. 9.

As a simple illustration of the principle upon which a parting assay is made, let us suppose we take twelve grains of eighteen-carat gold and add to this twenty-four grains of fine silver, and melt them in a small crucible (fig. 7), with a little borax. The alloy formed will thus contain two parts of silver to one part gold alloy. The crucible being withdrawn by the tongs (fig. 8) from the fire, is allowed to cool, after which it is struck with a hammer near the bottom to break it; the button *a* (fig. 9) is then extracted and placed for a few moments in a *pickle* of dilute sulphuric acid (oil of vitrol) to dissolve any borax flux which may attach to it. The button is next hammered flat, as at *b*, then *annealed*, by being made red hot, after which it is rolled between two steel rollers into a band or ribbon (*c*); this is now rolled up into a coil or "cornet" *d*, by the fingers and thumbs, as in rolling ribbon, after which it is carefully placed in a glass flask, and sufficient nitric acid poured into the flask to cover the cornet. The flask is then placed on a sand-bath, heated by a moderate fire, and allowed to stand until the red fumes at first given off cease to appear, when the acid liquor, which will have assumed a *green* colour, due to the copper dissolved from the alloy, is poured off, and a fresh supply of acid introduced as before, and the boiling resumed, until red fumes cease to be given off. After again pouring off the acid, the coil is washed with distilled water, and is then removed *very carefully*, for in its present condition it is exceedingly porous and fragile, owing to the large quantity of silver and copper taken out of it by the acid.* It is next placed on a flat piece of charcoal and made red hot with a blow-pipe flame, or heated in a small crucible. During the heating it gradually contracts, until, after being brought to a cherry-red heat and cooled, it is about

* If a much larger proportion of silver is alloyed with the gold, the latter will assume the form of a brown powder.

one-third its original size *e* (fig. 9). The gold, which is now all but absolutely pure, is next weighed, when (assuming the sample to have been *really* eighteen-carat gold) the product will weigh exactly *nine grains*, since this alloy (eighteen-carat) is composed of three-fourths gold and one-fourth silver and copper. In parting gold with nitric acid as above, a small trace of silver generally remains in the gold, but if the operation is carefully conducted, it is usually nothing more than a mere *trace*. In dissolving large quantities of gold and silver for the purposes of electro deposition, the author has *always* found *some* silver in the former, while from the latter he has, on several occasions, obtained enough gold to pay the cost of the acid used in dissolving it.

Assay of Gold Bullion.—The process of assaying gold bullion by the assayers of the Royal Mint and the Bank of England resembles that adopted at the Paris Mint. One-half gramme of the gold to be tested is accurately weighed, and then subjected to cupellation with the proper proportion of lead, and a quantity of silver, equal to about three times the weight of the gold supposed to be in the alloy. The bead, or button, after being removed from the cupel, is hammered flat, and rolled out as before into a ribbon, from two-and-a-half to three inches in length, which is then annealed, and, when cold, is coiled up into a cornet. This is now placed in a long-necked flask, containing about one ounce of pure nitric acid, and boiled until the red fumes cease to be evolved. The acid is then poured off, and the cornet twice boiled with fresh acid, for about ten minutes each time; in the last two boilings a piece of charcoal (half a charred lentil) is put into the flask to cause the boiling to be regular,

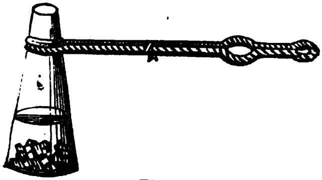


Fig. 10.

and not to occur in sudden bursts, which would be liable to break the fragile cornet, and eject a portion of the liquid from the flask. The acid is then poured off, and the cornet washed twice with distilled water; the flask is then filled with water, and carefully tilted over a small fire-clay crucible filled with water, into which the cornet falls, without breaking. The water which covers the coil is now poured off, and the crucible, containing the cornet, is gradually heated to redness in a muffle. The cornet is then cooled, and accurately weighed, and the fineness of the alloy is then determined by calculation.

The ingots or bars of gold in the bullion department of the Bank of England—with an inspection of which the author was recently favoured—average about 200 ounces in weight each. Arranged on a series of trucks, these massive lumps of gold present an imposing spectacle to the eye; and, apart from their enormous intrinsic value, what a history of laborious digging and washing, of amalgamating and mercury distilling, of disappointed hopes and lucky findings, may be connected with each glittering Lump of Gold! Or, when converted into standard coin of the realm, how much happiness—and misery—would the million-and-a-half sterling of dormant matter which lay in that little vault bring to those who may be destined to handle it hereafter! How much of it may be destined for the miser—and how much for the spendthrift? Perhaps it would be better for the common weal that the latter had the whole of it—if only for a day!

Quartation.—This name is given to an operation in assaying in which three parts of silver are alloyed with one part of gold before being submitted to the operation of *parting*, in order that its particles may be too far separated to protect the copper, lead, palladium, silver, and other metals with which it may be

contaminated, from the solvent action of the nitric or sulphuric acid used in parting.

Liquation.—This is a process of "sweating out" by heat the more fusible metals of an alloy. Metallurgists adopt this method in assaying and refining the precious metals, and procuring antimony and some other metals from their ores.

CHAPTER VII.

Gold Coinage—Alloys of Gold used in Coinage—Making the Standard Alloy—Rolling—Cutting out the Blanks—Stamping the Coin.

Alloys of Gold used in Coinage.—In an admirable series of Lectures "On the Alloys used in Coinage,"* delivered before the Society of Arts, by Professor Chandler Roberts, chemist to the Royal Mint, the author shows that he has taken great pains to search out the history of coinage from the earliest periods, and has brought to light a great amount of interesting matter, which is well worth perusing. "At a very critical period of the history of the alloys used for coinage," says the Professor, "one of the earliest of the English political economists, William Stafford, dedicated a little work to Queen Elizabeth, in which, under the form of a dialogue sustained by a knight, a doctor, and a merchant, he shows a keen appreciation of the conditions which a metallic currency has to meet. The doctor complains of the base alloys circulated as coins in the previous reign, to which the knight (who tells us incidentally

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* Cantor Lectures. *Journal of the Society of Arts*, July and August, 1884.

that he "was once in Parliament") replies:—"Forsooth, and such a dullard am I indeed, yet I cannot perceave what hindrance it should be to the realm to have this metal more than that for our coyne, seeing the coyne is but a token to goe from man to man when it is stricken with the prince's seale. . . . If ye prayse the gold for his weight and pliableness, led (lead) doth excel it in these pointes; if ye commend his colour, silver bye many men's judgement passeth him." The doctor then enters into a defence of the use of the precious metals for coinage, and publishes what he calls "A brief conceipte of English pollicye with regard to currency."*

"At the present day," Prof. Roberts remarks, "preference for one metal more than another, or for the simultaneous use of two metals, as standards of value, is widely and forcibly expressed; but although it is generally known that neither sovereigns nor shillings are made of pure gold or pure silver, few people have very definite ideas as to the composition of the alloys which are employed in coinage, and still fewer are aware that the amount of base metal added to the precious one, is guarded with the most rigorous care. As showing the national importance of the subject, it may be mentioned that between 700 and 800 tons of the alloy of gold and copper constitute the gold coinage of this country."

The Rev. Rogers Rudling, in his "Annals of the Coinage," says, "In the most early stage of society, when the wants of man were confined to the absolute necessaries of life, barter may be sufficient for every purpose of exchange. But this is a point at which society cannot long remain fixed; and the first step towards civilization introduces a train of wants that will require a more perfect medium of commerce; something which, by general

* London, 1581.

consent, shall be received at a determinate value for all other things." In uncivilized countries, fruits, skins, and shells have been employed as mediums of exchange, and M. de Perthes held that prehistoric stone implements were amongst the earliest mediums of exchange—as useful *necessaries* would naturally be; but Mr. Roberts reminds us that Artemus Ward refused to accept the coffin-plates and door-knockers offered to him for admission to his lecture, for although these were metallic, fairly portable, and may even have borne engraved devices, they did not meet the necessary condition of being universally acceptable!

For the purposes of exchange, it is absolutely necessary, as Mr. Roberts points out, that the commodity be of such general use as to ensure the certainty of its being readily acceptable, or as Rice Vaughan wrote in 1675, money should be made of a material which is not too common, "something not easy to be consumed with use, or spoiled for want of use," and portable. Stafford wrote, "I confesse precious stones do excell siluer, or yet golde as in value or lightness of carriage, but then, they may not be deuided without injury, nor yet put agayne together after they be once deuided."

It is more than probable that the earliest metallic coins were *cast* and not *struck*; and that the early form of Chinese money represented the value of certain articles of clothing. "These curious coins," says Mr. Roberts, "are said to go back four thousand one hundred years, and to have been made certainly in the time of Yaou, B.C. 3256. A coin in the Mint collection represents a Chinese shirt, and in fact pieces of cloth, or those metallic equivalents, were used, as Sir John Lubbock has pointed out, 'in some measure, as a standard of value, almost as grey shirting is even now.'" It is believed that the early Roman coins were struck or stamped, and not cast, and that when the latter mode of production was adopted, it was for the sake of cheapness

and speed. According to Kennett,* the most ancient money [brass] was first stamped by Servius Tullius, whereas formerly it was distinguished only by weight, and not by image. The first image was that of *Pecus*, or small cattle, whence it took the name of *Pecunia*. For a long time the Romans used no other money till after the war with Pyrrhus, when silver was adopted for coinage. "Last of all came up coin of gold, which was first stamped sixty-two years after that of silver." The first brass Roman coins were of 1 lb. weight.

The object of alloying copper with gold may be said to be two-fold. 1. Alloys are harder, and therefore less liable to lose in weight by constant usage than pure metals. 2. The substitution of a certain portion of the baser metal affords a considerable source of revenue. It is very important for public convenience, that the standard of all nations should be equal, in order to prevent loss, and to avoid the necessity for tedious calculations. Sir John Petters, writing in the 17th century, says: "It is good for the traveller to be skilful in different alloys, whereby, as a friend of mine told me, that he carried out £100 with him, and by his art of exchange in countries where alloys differed, he bore his charge of travel, and brought his stock home again."

Making the Standard Alloy.—In melting gold and copper to form "standard gold" small furnaces are employed, and the metal is melted in crucibles made from a mixture of graphite (blacklead) and fire-clay. The crucibles for melting gold usually hold about 1200 ounces; it was formerly the practice to mix both silver and copper with the gold, but since this caused some difficulty in the process of assaying, it is now the practice to alloy with copper only, whereby, also, a better coloured gold is produced. The essential characteristics of standard gold are

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* "Antiquities of Rome," by Basil Kennett, 1737.

ductility, durability, and uniformity of composition, in addition to which the coin produced from it must have the true "ring," as it is called, when struck against a hard substance.

It appears that at various periods of English history, the current coin was more or less debased, either to prevent its exportation to other countries or to augment the revenue—or from both motives. With regard to the debasement of coin generally, the famous antiquary, Sir Robert Cotton, in a speech made before the Privy Council in the reign of Charles II., observed, "What renown is left to Edward I. in amending the standard, both in purity and weight . . . . must strike a blemish upon princes that do the contrary." Professor Roberts, in tracing the history of the gold alloy of standard fineness,* 916·6 (22-carat), and the silver alloy of 925, the alloys used in this country for gold and silver currency, says: "And as the gold represents a large proportion of the coinage of the world, it may fairly claim to be the most important gold alloy in existence." He concludes his second lecture by promising to "show what great precautions are taken [at the Royal Mint] to secure accuracy in weight and fineness of the coinage, more especially in the case of the sovereign, which is so widely circulated, and the integrity of which is so implicitly trusted, that it may be said to epitomize the financial honour of the nation." How little does Mr. Childers's late attempt to debase the British half-sovereign, by reducing the value of it to a nine-shilling token, accord with the proud and honourable sentiment of the chemist to the Royal Mint!

In order to ensure perfect accuracy in the standard alloy, the *assays* (see page 37) are not wholly relied upon, but a means of

* "Standard fineness" indicates the amount of "fine" or pure metal present in any given alloy, and the degree of fineness is expressed decimally, pure gold or silver being considered 1000.—*Prof. Roberts.*

checking the results has been adopted for centuries, by the employment of *standard trial plates*, or pieces of metal of known composition which are assayed, side by side, with the coins, "so that any error affecting the coin assays also affects the trial pieces, and therefore the error can be allowed for." The oldest of these plates is a silver plate impressed with the dies of a coin of the time of Henry III. (1216-1272). In 1326 there is a record of the provisions of two silver plates for testing silver coined by Edward II., "one plate to be of the just weight before the fire, and the other such as it (the metal tested) ought to be after the assays." Many of the old trial plates were formerly kept in the Pyx Chapel, Westminster Abbey, and on the altar tomb believed to hold Hugolin, the first Chancellor of the Exchequer, there is a circular dish-shaped cavity on which a small furnace may have rested,* as it is believed to be probable that the trial of the Pyx was at one time carried on in this building. The old trial plates (which are found to be far from pure) were removed from the Pyx Chapel in 1842, to the office of the Queen's Assay Master, in the Mint. Professor Roberts states that the supplementary fine gold and silver plates prepared in accordance with instructions received by him from the Lords Commissioners of the Treasury in 1872, "proved eminently satisfactory. I have not been able to prepare, or to obtain from any source, gold of greater purity, even in small quantities. . . . In conducting official trials of the pyx, minute accuracy is secured by a final appeal from the standard plates themselves to pure gold or silver."

The difficulty of obtaining an *exact* standard, either of weight or fineness, in all the coins issued from the Mint has been long recognized by law, and therefore, for centuries, and in all nations, permission has been given for a certain deviation from the exact

* *Notes and Queries*, Nos. 17, 19, 20, and 23; 1880.

standard. The amount of such "remedy," as it is technically called in this country, has been changed periodically, but has gradually diminished as the art of coining advanced. Sometimes the privilege of applying the "remedy" has been taken advantage of, not only by the reigning sovereign—Queen Mary, for example—but also by the Master of the Mint—an abuse which could neither be attempted nor permitted in our own time. The scale of remedies was fixed by the Coinage Act of 1870, by which the remedy of fineness, in the case of gold coin, has a range of $+ \frac{2}{1000}$th.

The oldest trial plate of which there is any record, was made in the 17th year of Edward IV. Its composition was gold, 993·5; silver, 5·15; copper, 1·35. When gold coins were first introduced into England by Henry III. in 1257, they were 24 carats fine, that is pure gold. Edward III. was the first to use the standard 23-carat $3\frac{1}{2}$ grains fine, or 994·8, which is commonly called the "old standard"; it was last used for coinage in 1660, from which period, up to the present, the standard gold of England has been 916·6. Up to the year 1873 the alloy used for coinage consisted of gold, silver, and copper, but since that date copper only has been employed. The composition of standard gold now, is gold, 916·61; copper, 83·39. The lowest standard ever adopted in England (in 1544) was 833·4.

Rolling.—The bars of gold are next reduced in thickness by rolling as nearly as possible to that of the particular coin to be struck; in this condition the reduced bars are called "fillets." The last mill through which the metal passes is capable of a more accurate adjustment than those employed in the preliminary rollings, whereby the fillets are brought as nearly as possible to the thickness required for the coin. In order to ascertain whether the distance between the rollers is correctly adjusted, the operator cuts out a *blank*, as it is termed, by means of a hand-

press, provided with a ring, cutter, and die suitable to the size of the coin to be produced. He now weighs the blank to see if it is within the "working remedy." It is, however, found in practice that it is impossible to roll a fillet of perfectly uniform thickness in its entire width, from the fact that the rollers yield in the centre, causing the metal to be thicker at this part than at the edges; if this were not corrected in some way, a large number of the coins would be "out of remedy" as to weight, and would therefore have to be rejected. An apparatus called a *draw-bench* is employed, in which the fillets are rendered more uniform in thickness after passing through the rollers, and a blank is cut out and weighed, as before, to ascertain whether the draw-bench has been properly adjusted. The "working remedy" for sovereign fillets passed through the flatting mills, or rollers, is 0·5 gr., whereas in the case of fillets passed through the draw-bench, it is 0·2 gr. The fillets are weighed from the rolling-room to the *drag-room,* as it is called, and here, after passing through the draw-bench, they are taken to small shears, by which one end of the fillet is trimmed so as to render it square. The fillets are cut into lengths of about 15 inches. These are afterwards transferred to another apartment, to be cut out into *blanks,* which is effected by powerful presses.

Cutting out the Blanks.—The fillets having been thrown by the "tryer" into receptacles which indicate the particular cutting-out punches to which they are to be subjected, are taken in hand by a man who wipes off the oil, and then conveys them to the cutting-out room to be cut into blanks, and *scissel* (from the latin word *scindo,* to cut). The scissel is afterwards tied up in bundles for remelting.

The blanks are then weighed, or *pounded,* which, next to *trying* (which is effected by a gauge), is the most important of all the tryer's duties. They are weighed in drafts of about

720 ounces, and placed in bags to be conveyed to the marking-room. Here the edges (which are to protect the face of the coin from undue wear) are given to the blanks by means of a *compressing machine*, by which the diameter of the coins is reduced. They are next sent to the annealing-room, where they are freed from oil, and placed in copper tubes, a little charcoal being sprinkled on them to prevent the atmospheric oxygen acting on the alloy as far as possible. The tubes are next placed in a reverberatory furnace, in which they are gradually made red hot. The *crenated* edge, as it is termed, is next given by means of a milled collar, and the coins are then stamped in a lever press with the well-known image and superscription which renders them legal coins of the realm.

Stamping the Coin.—The action of the lever press is thus described by Mr. Roberts :—" A sketch of a portion of the lever machine which bears the dies will be all that is necessary to make clear the principle by which it works. The blanks [that is the discs of metal ready for stamping] are placed at B (fig. 11) between the dies, D D, and the pressure is imparted by the tozzle joint, E, and bent lever, L, and not by the partial revolution of a cylinder, as in Briot's machine. The edges of the coin may, at the same time, be marked with lines, or with a device, by means of a collar in the plate, C. It is strange," remarks the Professor, " that the method of striking in a collar was not adopted earlier. The earliest reference I have been able to find, to a coin marked with letters on the edge, is a gold piece of Henry II. of France dated 1555."

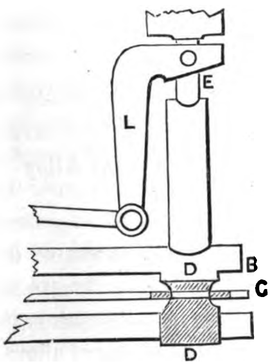

Fig. 11.

It is believed that Leonardo da Vinci, the great painter, first suggested the use of a collar fitting round the blank.

As the coined money issues from the press it is collected in trays and examined, and all imperfect coin, called "brockage," is picked out, and the perfect coin weighed out in drafts of 701, or 180 ounces. The duties of the tryer necessitate the employment of a person of great calmness of judgment, keen perception and steadiness, with considerable energy, for upon him depends the accuracy of all the operations of coining; he is not unfrequently required to manage his work so that upon 5,000,000 of sovereigns coined, he should reach to within one sovereign of the calculated value.

It will be readily understood that, in the slight sketch we have given of the art of coining, we have only been able to convey a general idea of the principal operations connected with the conversion of bullion into current coin.

CHAPTER VIII.

Alloys used in Jewellery—22-carat Gold—20-carat Alloy—18-carat Alloy—16-carat Alloy—15-carat Alloy—14-carat Alloy—12-carat Alloy—10-carat Alloy—8-carat Alloy—Testing Gold with Nitric Acid.

Alloys of Gold used in Jewellery.—Although it would not be practicable, in our limited space, to enter fully into the art of alloying gold for the manufacture of jewellery, a brief outline of the system adopted, and the composition of the principal alloys, will, doubtless, be interesting. In preparing his alloys, the jeweller adopts certain formulæ, which represent the proportions of gold, silver, and copper to be united to form the various

kinds of gold—or, rather, alloys—required for the different classes of work. Pure gold, which is spoken of as "24-carat * fine," is too soft to be employed for jewellery purposes; it is, therefore, always combined with more or less silver and copper.

22-carat gold is the highest standard used by goldsmiths, and consists of gold, 18 dwt. 8 gr.; silver, 16 gr.; copper, 1 dwt. (=one ounce). The silver and copper are first put into a crucible, with a little borax as a flux, and heated in a forge by a charcoal fire, and when these are perfectly melted, the gold is added, and the heat continued until the whole are well fused. The molten alloy is then carefully poured into an iron mould, called a *skillet*, and when cold, the *ingot* may be rolled out to any desired thinness. Strips of the alloy may then be cut off and hammered, and then drawn through perforated steel plates, in the form of wire, if such be required. It is this alloy which is employed in England and Scotland for making wedding rings; in Ireland they are made from a much lower standard, as it is not compulsory to have them Hall-marked in that country. The *gold solder* used for uniting joints of this alloy is composed of 22-carat gold, 1 dwt.; silver, 3 gr.; copper, 2 gr. When it is desired to give a fine gold appearance to the surface of articles made of this alloy, this is effected by immersing them for a short time in a fused mixture of nitre, common salt, and alum, to which a small quantity of water is added. These "colouring salts," acting upon the silver and copper of the alloy, remove them from the surface, leaving pure gold only on the surface—hence the term "colouring" is applied to the process.

The 20-carat alloy is employed for the better kind of

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* In *assaying*, or determining the proportion of gold in an alloy, a *carat* is twelve grains weight. In diamond weighing, a carat is four grains.

cast jewellery, such as rings in which soft or fragile stones (as emeralds, opals, turquoises, &c.) are to be set. Being a very soft and ductile alloy, it is easily pressed over the edges of the stones, without danger of injuring them. The *solder* used for this alloy consists of: 20-carat gold, 1 dwt.; silver, 3 gr.; copper, 2 gr. Articles made with this alloy are "coloured" in the same way as the former alloy, but being of a lower standard, the colouring salts act more freely, and therefore produce the desired effect in less time.

18-*carat Alloy.*—The most important alloy—since it is used for watch-cases, mourning-rings, and many other articles which are required to be stamped with the "Hall" mark—is what is termed the "18-carat alloy;" it is the lowest standard marked by the Goldsmiths' Hall. It consists of gold (fine), 15 dwt.; silver, 3 dwt.; copper, 2 dwt. This is for what is called the "bright alloy," and is employed for work which has to be left *bright*. When required for "coloured work," the *copper* is used in excess instead of the silver, as in the above formula. *The solder* is formed of 18-carat gold, 1 dwt.; silver, 3 gr.; copper, 2 gr. For filigree work, chains, or other light work, the following formula is sometimes used: 18-carat gold, 1 dwt.; silver, 4 gr.; brass, 2 gr.

Amongst the many frauds that have been practised with respect to "Hall-marked" jewellery (as mourning-rings, for example) is the following:—A narrow plate of the gold alloy, much thicker than is required for its *real* purpose, ostensibly for what is called a "widow's hoop," is sent to the Hall to be marked. When returned from the Hall, *marked,* it is hammered out thin, and a heavy outside soldered on to it of inferior gold; or a *lining,* as it is termed, of a mourning-ring, and two very light wires with it, as though for edges, are sent to the Hall; when returned, the lining is used, perhaps, for a very heavy ring, and the wire

edges sent are not used at all. But the most dangerous of all methods for evading the "Hall," is getting one ring of a dozen marked in the straight—that is opened out—then with a fine facing of rotten-stone dust, casting off the remainder of the dozen rings with an inferior alloy—by which, of course, the Hall-mark is cast at the same time!

16-*carat Alloy*.—The next alloy worked is the 16-carat alloy, which is composed of gold, 13 dwt. 8 gr.; silver, 2 dwt. 8 gr.; copper, 4 dwt. 8 gr. This alloy was formerly much used for making *filigree* jewellery, that is the light wire-work so much in vogue at the end of the last century, for ear-rings and many other ornamental purposes. The solder used for this alloy consists of 16-carat gold, 1 dwt.; silver (fine), 4 gr.; brass, 1 gr. The 16-carat alloy is generally used for chains, bracelets, and most of the articles retailed under the name of *fine gold*.

The 15-*carat Alloy*—which is generally considered the lowest standard that will bear "colouring"—is composed of fine gold, 12 dwt. 12 gr.; silver, 2 dwt. 12 gr.; copper, 5 dwt. The chief difference between this and the last alloy, is that it is lighter, and exhibits a larger surface for its weight. It is employed for the same purposes as the former, and the solder contains one grain more brass than that used with the above.

The 14-*carat Alloy*, which in England is termed "chasing gold," and in Scotland and Ireland "bright fine gold," is composed of fine gold, 11 dwt. 16 gr.; silver, 6 dwt.; copper, 2 dwt. 8 gr. This forms a hard and tough alloy, and is used for the stems of pins, spectacle frames, &c. It was formerly used for chains, such as the "curb," seals, brooches, &c. *The solder* employed is composed of 14-carat gold, 1 dwt.; silver, 6 grs.; brass, 3 grs.

12-*carat Alloy*.—This is known by the name of "jewellers'

gold." It is of a deep red colour (from the large proportion of copper), is soft and ductile, and, from the ease with which it may be worked, is much employed by jewellers and goldsmiths as a metal for general use. It is not soldered with *gold solder*, as in the former alloys, but with *silver solder*, which is composed as follows:—fine silver, 2 parts; brass, 1 part. These are fused together at a low heat, and the alloy—or solder—is then cast in a flat mould or skillet, and afterwards rolled out, and when required for use is cut up into small pieces about $\frac{1}{16}$ of an inch square. Silver solder is an exceedingly useful alloy for uniting two surfaces of the same, or different metals, and it fuses or *runs* at a very low heat.

The 10-*carat Alloy*, like the 15-carat, is often used as a substitute for a better alloy, when quantity rather than quality is desired. It consists of fine gold, 8 dwt. 8 gr.; silver, 3 dwt. 20 grs.; copper, 7 dwts. 20 grs.

8-*carat Alloy*.—The lowest standard of gold that will resist the action of nitric acid (the legitimate test for gold) is the 8-carat alloy, which is composed of fine gold, 6 dwt. 16 gr.; silver, 8 dwt. 21 gr.; copper, 4 dwt. 11 gr. This is the lowest "legitimate" alloy worked by goldsmiths, but unfortunately it is not the lowest alloy which is sold under the name of "gold."

A very "clever" alloy, in which brass forms an important element, is formed as follows, and is much used for cast solid rings, since a ring made from it looks as well as one that would cost more for material alone than the entire cost of workmanship and material if this alloy be used: gold, 1 oz.; brass, 1 oz.; silver, 7 dwt. 8 gr. The alloy requires to be prepared with great care, otherwise the zinc of the brass (the latter being an alloy of copper and zinc) will evaporate, or *volatilize*, in which case the alloy will be *red*, owing to the absence of the white metal—zinc.

Mr. Watherston, in his "Art of Assaying," says: "It has recently been found that gold of the quality of 12 carats, or less, if alloyed with *zinc* instead of the proper quantity of *silver*, presents a colour very nearly equal to that of a metal at least $2\frac{1}{2}$ or 3 carats higher, or of 8*s* or 10*s* an ounce more value, and the consequence has been that a large quantity of jewellery has been made of gold alloyed in this manner; and the same has been purchased by some shopkeepers, very much to their own loss, as well as that of the public, inasmuch as galvanic action is produced after a time upon gold so alloyed, by means of which the metal is split into several pieces, and the articles rendered perfectly useless. *Gold chains, pencil cases, thimbles,* and *lockets* are the articles of which the public and the shopkeepers will do well to take heed, as these have amongst other things been so constructed."

Testing Gold with Nitric Acid.—The article to be tested is rubbed upon a *touchstone,** which is usually of black basalt, but a piece of good black pottery ware, or even ordinary slate, will answer the same purpose. The mode of using the stone is to rub the article upon it until a metallic streak is produced. If a small drop of nitric acid, applied from the glass stopper of the bottle, be placed on the mark, if the gold be pure, or above 14 carats (unless a very large proportion of *copper* be in the alloy), *no* change will be exhibited. An alloy between 14 and 8 carats will exhibit a certain *tarnish,* or discolouration, when the acid is applied, which enables an experienced eye to form an *approximate* judgment as to the quality, and consequent value. If the gold be above 8-carat, or if the article be not of gold, or alloy of gold, the metallic spot will turn *green,* and the fumes of nitrous gas will be evolved, when the tested article may be condemned; if the article be brass, gilt, or German silver, the same result will

* Or "Lydian Stone," as it was formerly called.

be obtained; but if it be silver, gilt, the action of the acid will produce a black or dark brown stain. In testing gold jewellery, where a more reliable estimate is necessary, *touch-needles* are used in connection with the *touchstone*. These needles are made in sets, containing gold of different degrees of fineness, and differently alloyed with copper and silver. The *streak* produced on the touchstone by the article to be tested, is compared with a similar streak produced by one or more of the needles, and in this way a very fair estimate is formed as to the value of the article under examination.

Frequently articles are ticketed in the shop-windows as "genuine gold," "real gold," or "fine gold," which are nothing better than *plated metal*—that is brass, with a very thin layer of very poor gold on the exterior surface. Being prettily stamped, or *struck* into shape—either as a brooch, ring, or pin—and tolerably well put together and finished, the articles assume a virtue which they do not possess, until a moderate amount of wear exposes the baser metal at the edges and sharper angles; cheap rings and studs frequently exhibit this eccentricity. A drop of nitric acid, applied to the *edges* of such articles, even when quite new, would probably divulge the secret of their manufacture.

CHAPTER IX.

Gold Beating—Leaf Gold—The Operation of Gold Beating—Casting—Rolling—Beating.

GOLD-BEATING—*Leaf Gold.*—When we consider that the malleability of gold is so great that it may be beaten into leaves which do not exceed the two hundred and ninety-thousandth part of an inch in thickness, and that a single grain of gold can thus be spread to the extent of 75 square inches of surface,

we may begin to realize the remarkable extensibility of this most useful metal. Again, its *ductility* is such that a grain may be drawn out into 500 feet of wire, and Réaumur, by rolling out a fine silver-gilt wire, reduced the coating of gold to the *twelve millionth* of an inch in thickness, and yet, under the microscope, no imperfection could be detected. Even this remarkable degree of attenuation may, the Author believes, be exceeded by electro-chemical agency, as in the ordinary process of electro-gilding.* Indeed, the extent of metallic surface—especially of brass, copper, and some varieties of German silver—which a single grain of gold will actually cover, when deposited from its solution by electricity, is almost incalculable.

Taking a cubic inch of gold to weigh 4900 grains, it will be found that the gold leaf (1 grain being made to spread over 75 square inches) is 367,500th part of an inch in thickness, or about 1200 times thinner than ordinary writing paper. Therefore, if 367,500 leaves of gold were piled one above another they would form a pile only one inch in height, while the same number of leaves of paper would form a pile half as high as the Monument of London!

In the Great Exhibition of 1851, Mr. Marshall, a London gold-beater, exhibited specimens of gold leaf composed of various alloys of copper and silver, by which he produced leaves of various shades of colour, from red to nearly white. There were 12 specimens in all, whose colours were respectively designated as red, pale red, extra deep, deep, orange, lemon, deep pale, pale, pale pale, deep party, party, and fine gold. The deeper colours were produced by adding from 12 to 16 grains of copper per ounce of gold, and the medium colours were obtained by adding silver only to the gold, in proportions

* Some electro-gilt articles in the shop windows might be considered in very good society, if placed by the side of Réaumur's gilt-wire!

varying from 12 to 20 grains up to twenty pennyweights per ounce. It is a fact well known in electro-gilding, that various shades of colour may be given to gilt work by adding small quantities of silver and copper solutions to the gilding bath.

The operations of gold-beating are: 1. *Casting the gold into ingots.* 2. *Rolling.* 3. *Annealing.* And 4. *Beating.*

Casting.—The gold is first melted in a crucible (fig. 7), with a little borax as a flux; when melted, it is poured into cast-iron ingot-moulds, previously heated, and greased inside. The ingot is then taken out of the mould, and *annealed* on hot ashes, which softens it and at the same time burns off the grease. Each ingot weighs about two ounces, and is about three-quarters of an inch in width.

Rolling.—The ingot is then passed between a pair of highly polished steel rollers, by which it becomes extended in length; the rollers are brought closer together by means of adjusting screws, and the ingot again passed through, when it becomes still further lengthened. After passing through the rollers several times, the *ribbon* of gold, as it is termed, is annealed, by being made red hot, after which it is again rolled; the operations of annealing and rolling (the rollers being brought closer together each time) are kept up until the ribbon is reduced to such a degree of thinness that a square inch will weigh six and a half grains.

To prepare the rolled metal for *beating*, it is cut up into squares of one inch each, which are piled one above another, with a piece of calf-skin vellum, about four inches square, between each. About twenty pieces of the vellum are placed both at the top and bottom of the pile. The pile is kept together by being forced into a case of strong parchment, open at the ends; a similar case is placed over this, at right angles to the first, by which the whole pile is enveloped so as to bear hammering without disturbing the layers of metal and vellum.

Beating is performed on a powerfully constructed bench, in which is fixed a solid block of marble, about 9 inches square, and which is enclosed by a wooden frame, except the front, where a leather apron is attached to receive any fragments of gold that may fall out of the packet during the process of beating. The hammer, which is provided with a short handle, is of about fifteen or sixteen pounds weight. This the beater takes in one hand, and strikes the pile fairly on the middle, with well-timed strokes, while with the other hand he frequently turns the pile over, so as to equalize the hammering, and this he does with such dexterity that he can turn the pile after every second stroke without losing a blow. After beating for some time, the packet is examined, and the position of the leaves shifted, so as to equalize the effect of the beating. When the leaves have been beaten to nearly the extent of the vellum, they are removed, and cut with a knife into four equal squares, or about their original size, but of course considerably thinner. They are then again made up into a packet as before, but instead of vellum, skin prepared from ox-gut is interposed between them. A smaller hammer, weighing about ten pounds, is now used, and the beating continued until the metal is nearly the size of the skins, but during the operation the packet is frequently unfolded to loosen the leaves, otherwise they would be liable to be broken. The leaves are next taken out of the packet and spread on a cushion, and each cut into four square pieces, by means of two pieces of cane, cut to very sharp edges, and arranged in the form of a cross, and attached to a board. By gentle pressure, this implement divides the leaf into four equal pieces, which are again made into a packet as before, and beaten out until they average about 3 to 3½ inches square, when the operation is complete. Although the gold leaf might be still further reduced, the difficulty of handling it in its present degree

of attenuation would render it unprofitable to do so. The leaves are then put into small books of thinnish paper, which is previously rubbed over with red chalk to prevent the gold from adhering to it.

CHAPTER X.

Uses of Gold in the Arts—Oil Gilding—Varnish Gilding—Distemper Gilding—Leaf Gilding—Letter Gilding for Books—Letter Gilding for Signboards—Gilding with powdered Gold—Chemical Gilding—Grecian Gilding—Water Gilding—German Gilding—Button Gilding—Cold Gilding—Gilding Liquor—Electro-gilding—Gilding with Gold Bronze—Gold Shells—Gold-Toning—Employment of Gold in Dentistry—Gold Wire—Gold Thread.

AMONGST the numerous purposes to which gold is applied in the arts, the various methods of *gilding*, or covering wood, metals, or other surfaces with a layer or film of gold, may be considered one of the most useful, and probably one of the most ancient to which the precious metal has been applied. The processes of gilding may be divided into 1. *Mechanical gilding*, in which leaf-gold is the chief material used; and 2. *Chemical* gilding, as electro-gilding, water-gilding, &c. Of the mechanical methods, gilding with gold-leaf stands pre-eminent, when we bear in mind the universal application of this delicate metallic film in the ornamentation of picture-frames, books, the interior and exterior of public and private buildings, and to innumerable other purposes.

Oil Gilding.—This is applied to woodwork, plaster, metal, &c., and consists of the following operations:—1. The surface

is prepared by a coating of white lead and dry oil. 2. Another coat is given, made with calcined white lead ground in linseed oil and turpentine. Several coats of this are given, at intervals of not less than twenty-four hours. 3. The *gold colour* or paint is applied, which is generally *gold size.* 4. When the gold colour becomes partially dry and sufficiently sticky, the gold-leaf is applied, and pressed on with a wad of cotton wool, or a very soft brush. It is then left for several days to harden. 5. A coat of spirit varnish is then given, and the object is cautiously passed over a *chafing dish* of red-hot charcoal, care being taken not to allow the heat to blister or discolour the work. 6. The work is *finished off* with pale *oil varnish.*

Varnish Gilding.—This is a modification of the above, applied to furniture, mirrors, picture frames, &c., the surface being *highly* varnished and polished before it receives the size and gold colour ; after the gold-leaf has been applied as before, and the gilding has become quite dry, a coat of spirit varnish is given, fumed with the *chafing dish,* as above, and this is followed by several coats of good copal varnish, at intervals of two or three days each. The work is then polished with tripoli and water.

Distemper Gilding.—This is applied to wood, plaster, &c. The wood is first coated with size, and next with successive coats of size thickened with whiting, or plaster of Paris, until a good "face" is produced. After each coat is dry, the object is rubbed perfectly smooth with *fine* glass paper. It is then coated with gold size, and when this is *nearly* dry, the gold-leaf is applied, and afterwards burnished with an agate, or dog's tooth burnisher.

Leaf Gilding.—This term is given to the gilding of paper, vellum, &c., by applying leaf-gold to the surface, previously prepared with a coating of gum-water, size, or white of egg.

Letter Gilding for Books.—The gold letters on book-covers are thus formed:—Finely powdered gum mastic is dusted over the surface to be gilt; an iron or brass tool, having the design of the lettering or ornamentation upon its face, is heated to a suitable temperature, and then gently pressed upon a piece of leaf-gold, which slightly adheres to it; the tool is then gently pressed upon the book-cover, when the powdered mastic softens, and retains the gold. The loose gold and powdered mastic are then brushed off. Gold-leaf will adhere to leather without the mastic, but not so firmly. For gilding the *edges* of the *leaves* of books and paper, they are first cut perfectly smooth, and then brushed over with a solution of gelatine or albumen; when dry, the gold-leaf is applied, and is afterwards rubbed over with a burnisher.

Letter Gilding for Signboards, &c.—The letters or other designs are first painted with *yellow paint*, then with *oil gold size*, and when this is *nearly* dry, the leaf-gold is applied—care being taken to shield it from the wind, lest it be blown away or crumpled up before being applied. A coat of varnish is then sometimes given.

Gilding with Powdered Gold.—The so-called *gold-bronze* is applied to a variety of purposes. For gilding glass, porcelain, &c., the powdered gold is mixed with gum-water and a little borax, and with this mixture the design is painted by means of a camel's-hair pencil; the article is next heated in an oven or furnace, when the gum becomes burnt off, and the borax becomes *vitrified*, and cements the gold to the surface. In this way, the *names*, *dates*, or any fancy design may be *permanently* and easily fixed on glass, china, &c. For *illuminating* purposes, powdered gold mixed with gum-water and applied with a camel-hair pencil is generally used. For decorative purposes, or or touching up "portions of gilt frames from which the gold has

been rubbed off, gold-bronze, mixed with varnish and applied with a soft brush, may be used.

Chemical Gilding.—As in the above brief summary of mechanical gilding, this subject must be treated briefly, under different heads, since they have little or no connection with each other.

Grecian Gilding.—Equal parts of corrosive sublimate (*bichloride of mercury*) and sal ammoniac are dissolved in nitric acid, and a solution of gold made with the mixture. After being slightly evaporated, the liquid is applied with a brush, or otherwise, to the surface of *silver*, which turns black, but on being heated, exhibits a fine gold appearance.

Water Gilding.—Previous to the discovery of the art of *Electro*-gilding, or depositing gold by means of the voltaic battery, *water-gilding*, or more properly, *mercury* gilding, was commonly adopted for most purposes in the coating of *metals* with gold. Since mercury, or quicksilver, was a necessary ingredient in the process, the persons who worked in the art suffered most severely in health, and seldom attained old age. The introduction of electro-gilding—while it furnished additional employment to many persons "outside the trade"—eventually, but not willingly, found its way into the mercury gilder's establishment, and except for certain special purposes to which water-gilding is still applied, it entirely superseded the unwholesome mercury process, and electro-gilding was soon found to be applicable to many purposes for which the older method would not be adapted.

In water-gilding, an *amalgam* of gold and quicksilver is first formed, by heating the required quantity of standard gold in a crucible; when the gold is red-hot, the proper proportion of quicksilver is poured in—the proportions being about eight parts by weight of mercury to one part gold—and the mixture is

gently stirred with an iron rod until the gold is dissolved.* The *amalgam* is then poured into a vessel containing cold water; the water is next poured off, and the amalgam squeezed in a chamois leather bag, through the pores of which the unalloyed mercury oozes. The remaining amalgam contains about 57 grains of gold and 33 grains of mercury in each 100 grains. The surplus mercury, which contains a good deal of gold, is preserved for future use. The water-gilder next makes a *solution of mercury*, by dissolving a small quantity of the metal in nitric acid, and this is afterwards diluted with water. The article to be gilt—say a silver watch-case—is first "pickled" in a very weak solution of sulphuric acid (oil of vitriol), and then well rinsed. The gilder now takes a tool called a *scratch-brush*—which consists of a bundle of very fine brass-wire, bound with copper-wire—and first dips this in the mercury solution, and then passes it over the lump of amalgam, by which a small quantity of the alloy becomes attached to the brush. He then paints the article with the pasty amalgam, repeatedly taking up a fresh supply with the brush, until the entire surface is well coated. The article is then rinsed in clean water, and dried, and is ready for the next operation. To *expel* the mercury —which volatilizes or becomes converted into vapour at a heat of 662° Fahr.†—the article is heated in a charcoal stove until all the mercury is driven off, leaving the coating of gold not only on the surface, but to some extent *alloyed* with the silver of which the article is composed. Sometimes a second coating, or even several coatings of gold are given to work of superior quality. The work is afterwards coloured with *gilders' wax*, or the colouring salts before mentioned; it is then scratch-

* It is a remarkable property of quicksilver that it is capable of dissolving gold, silver, copper, zinc, and tin.

† Even at ordinary temperatures, mercury slowly evaporates.

brushed at a lathe, and is afterwards *burnished* with steel and blood-stone burnishers, moistened with soap and water, vinegar, or ale.

German Gilding.—Bonnet's Process.—This process consists in dissolving gold in *aqua regia,* a mixture of two parts hydrochloric acid (muriatic acid) and one part nitric acid. The solution is then diluted with water and bicarbonate of potash added, the whole being boiled together for about two hours. The articles to be gilt are first cleansed from grease by being immersed in a hot solution of potash, after which they are scratch-brushed, then rinsed, and next suspended by wires in the gold solution (boiling hot), being kept in motion all the time, for a few seconds or minutes, according to the quality of gilding required.

Button Gilding.—At that period of our history—say half a century ago—when blue coats with gilt buttons were in vogue, the demand for gilt buttons was exceedingly great, and it is not to be wondered at that the Birmingham manufacturers—ever remarkable for their skill in making a little gold go a long way! —found a means of imparting to buttons made from brass the rich colour of gold without sacrificing too much of the precious metal.* Perhaps this love of economy—and profit—was carried a little too far. Anyhow, an Act of Parliament (which we believe has never been repealed) had to be passed to compel manufacturers to use not less than *five grains* of gold for every gross of buttons, *gilt on both sides,* each button being one inch in diameter. How it would be practically possible to detect any infraction of this salutary Act it would be difficult to conceive. The process of gilding buttons was a variety of *water* or *wash* gilding. The buttons were first polished at the lathe, and then

* An old joke about the *Brummagem* proportion of gold in gilding, gave the estimate as "a half-sovereign to a copper coal scuttle!"

thrown into a pan containing a little *gold amalgam*, and as much dilute nitric acid as would cover them, and were briskly stirred about until they assumed a *silvery* appearance, when they were removed and washed in clean water. They were then subjected to sufficient heat to drive off the mercury, then allowed to cool, and afterwards brightened by shaking them up with stale beer.

Cold or Rag Gilding.—This process consists in saturating a piece of rag with a solution of *chloride of gold* and pure copper dissolved in *aqua regia*, and then drying and burning it to *tinder*, by which the metals become reduced to the metallic state in very fine particles. The article to be gilt (either copper or brass), after being polished, is rubbed with the ashes of the burnt rag, moistened with salt and water, by means of a piece of cork; in this way a slight coating of gold is imparted, and the article is afterwards burnished.

Gilding Liquor.—If a little chloride of gold be dissolved in *ether*, the solution formed may be employed for gilding the initials, or other design, upon steel. A film of wax should first be given to the object to be gilt, and the letters or pattern traced with some pointed instrument *through the wax;* if a little of the solution be now applied with a camel-hair brush to the design, and allowed to remain until the ether has evaporated—only a few seconds—a deposit of gold will take place upon the parts from which the wax has been removed. If the object be gently heated, and the wax wiped off by a piece of cotton wool moistened with turpentine, the gilt pattern will be seen to advantage. Or, if the ethereal solution of gold be mixed with a little jewellers' rouge, the mixture may be employed as a *paint*, and when the required design has been drawn upon the metal, the rouge may afterwards be washed away, when the design will appear in gold.

Electro-gilding.—By far the most important and useful method of depositing gold upon *metallic* surfaces, is that known as *electro-gilding*. There are many different solutions of gold employed for this purpose,* but the following will give the reader an idea of their general composition:—Fine gold, 12 grains; dissolve in *aqua regia* (*nitro-hydrochloric acid*), taking care not to use an excess of acid. Add distilled water half a pint; next, dissolve cyanide of potassium one drachm, in about one ounce of water; add a little of this solution to the former, when a slight *precipitate* will be formed, which, on the addition of a little more cyanide solution, will disappear; the remainder of the cyanide solution is then added. The solution should then be filtered through white blotting paper, and moderately heated before use. A small Daniell's battery, which consists of a copper cylinder for the outside vessel (fig. 12), to which a binding-screw for connecting the *positive* conducting wire is attached. This vessel is partly filled with a solution of *sulphate of copper*, to which a little sulphuric acid is added. A *porous cell*, made from unglazed earthenware, stands in the centre of the copper battery cell, and within this is a zinc bar with binding-screw attached, for connecting the *negative* conducting wire. The porous cell is either filled up with a strong solution of salt or sal ammoniac, or, if the zinc bar be *amalgamated*—that is rubbed over with mercury by means of a piece of flannel dipped in hydrochloric acid, or with dilute oil of vitriol. A small strip of gold as an *anode*, or dissolving plate, is connected to the wire

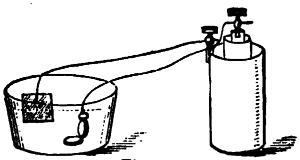

Fig. 12.

* For full *practical* instruction in gilding and all other processes of electro-deposition, the reader is referred to the author's work on "Electro-metallurgy." (Weale's series.)

proceeding from the copper cylinder, and this, when the battery is in use, is immersed in the gold solution, its purpose being to re-supply the solution with gold in the proportion in which it is deprived of that metal by the articles being gilt. When all the above arrangements are complete, which are shown in fig. 12, the article to be electro-gilt is first cleaned by brushing with silver sand, soap and water, or a mixture of rotten-stone and finely-powdered pumice and water; it is then well rinsed, and slung by a piece of thin copper-wire, the free end of which is to be twisted round the *negative* wire (the one connected to the zinc of the battery) and the article then immersed in the warm gold solution. When the article (say the *bowl* of a salt spoon) has been in the solution a few seconds, it will receive a film of gold, which will increase in thickness in proportion to the length of time it is immersed; from three to four minutes, however, will be quite long enough to give a fair coating to such an object, which is not subject to much wear and tear. A strip of fine gold (for the *anode*), weighing 1 dwt., or 24 grains, will impart a rich golden surface to a great number of small articles, such as brooches, rings, pins, &c., and by renewing the anode as it becomes used up, and replacing the exciting solution in the porous cell, the *petite* arrangement we have indicated is capable of doing a considerable amount of small work; a little addition of cyanide to the solution occasionally will, however, be necessary.

Gilding with Gold Bronze.—Powdered gold is used by artists, and also by japanners. It may be mixed with gum or varnish, and applied with a camel-hair pencil.

Gold Shells are prepared by brushing them over with gold-leaf or powdered gold ground up with gum-water.

Gold Toning, in photography, is effected by adding a small quantity of a solution of chloride of gold to a solution of hypo-sulphite of soda. The photographic prints, after being well

washed, are immersed in the *toning bath* of gold for a few seconds, or minutes, as the case may be, when the brick-red colour of the washed print generally assumes a rich purple-brown tone. The proofs are then well washed in water, and after further immersion in a solution of "hypo" without gold, and subsequent washings, they are dried, when they assume the pleasing sepia tones so generally admired when the work is properly done.

Employment of Gold in Dentistry.—It is very important that the gold used for plates and wires for attaching artificial teeth should be of such a high standard as to resist, *absolutely*, the action of the saliva. If such is not the case, but an inferior alloy substituted, this is likely, in course of time, to cause serious injury to the person in whose mouth the article is worn. Mr. Robinson, in an important pamphlet upon this subject,* says, "Among the adulterations we must rank the employment of alloys containing the baser metals in larger proportions for dental purposes; the placing of these alloys where they are exposed to the action of the secretions of the mouth and stomach, and atmospheric air—conditions most favourable for the oxidation and corrosion of the metals, and the formation of salts which, being conveyed to the stomach with the saliva, exert injurious influence on the health of the individual. . . . The saliva is very frequently *acid*, from the presence of lactic, acetic, and muriatic acids, but most frequently lactic acid. Again, matters which lodge in the teeth, or hollows in contact with metallic plates or stoppings, undergo acid fermentation. . . . There is, probably, no department of the dental profession which affords so much scope for quackery, imposition, and

* "The Gold, its Alloys, and other Metals used by Dentists," By James Robinson.

extortion, as that of supplying artificial teeth and stopping carious teeth. . . . The advertizing quacks should be avoided who use deleterious, because impure, alloys."

We know that it is the practice for unscrupulous dentists to manufacture their plates from a *very* low standard alloy, and to have them electro-gilt before attaching the teeth. It is needless to say that in a very moderate time the film of gold becomes worn off, when the pernicious alloy becomes fully exposed to the action of the saliva, and other matters, which are well known to possess a solvent action upon the inferior metals. In course of time, the victim of imposture—besides being constantly annoyed by a metallic taste in his mouth—finds his digestive organs impaired by the continual absorption of deleterious metallic salts. Moreover, there is no doubt whatever that when inferior alloys come in contact with the saliva, *electrical action* is set up, by which the more oxidizable metal of the alloy becomes dissolved, and eventually finds its way to the stomach.

It is found that pure gold, or even standard gold, are too soft for dental purposes; it is the practice, therefore, amongst respectable dentists, to use 18-carat, or, more frequently, 19-carat gold for their plates. If a gold plate, after continued wear, becomes discoloured, it is a sure sign that it was made from an alloy far below 18-carat. With respect to the stopping of decayed teeth with gold, this is frequently done with an amalgam of gold and mercury; but it has been found that bad cases of *salivation* (due to the mercury) have sometimes occurred from this cause.* "The best, and only safe material for stopping decayed teeth," says Mr. Robinson, "is *pure leaf gold*," which is very easily packed into the hollow of a carious tooth.

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* Sometimes an amalgam of silver and mercury is used for stopping decayed *front* teeth, but this is even more objectionable.

Gold Wire is produced by drawing fine gold through a steel *draw-plate*, with diminishing holes, until it has been finally passed through the hole that reduces it to the gauge or thickness required. During the operation of drawing, the wire has to be occasionally annealed, since it becomes considerably hardened while passing through the various holes of the draw-plate.

Gold Thread, or *Spun Gold*, is a flatted silver-gilt wire, wrapped or laid over a thread of yellow silk, by twisting with a wheel and iron bobbins. The silver-gilt wire used to be made by encasing a silver rod in gold leaf and then drawing it into wire of a certain thickness; it was afterwards flatted by being passed through rollers. By Act of Parliament, formerly, 100 grains of gold to one pound, or 5760 grains of silver had to be employed.

With regard to the employment of gold in the arts and manufactures, for ornamental and other purposes, the reader may probably be surprised to hear that it is estimated at fifteen million pounds'-worth annually; this, on the production of 1881, would leave only six and a half million pounds'-worth for coining purposes each year.

CHAPTER XI.

Preparations of Gold—Pure Gold—Chloride of Gold—Cyanide of Gold—Double Cyanide of Gold—Ammoniuret of Gold, or Fulminating Gold—Grain Gold—Oxides of Gold—Sulphuret of Gold—Purple of Cassius—Phosphuret of Gold—Powdered Gold, or Gold Bronze—Amalgam of Gold.

Pure Gold.—This may be obtained in the small way by adding to a solution of chloride of gold a solution of sulphate of iron, a brown precipitate is formed, which, after repeated

washing with hot *distilled* water, is *chemically pure.* If this powder, when dry, be rubbed in an agate mortar it acquires the characteristic metallic lustre of pure gold, and may be used for all the purposes for which *gold-bronze* is used.

Chloride of Gold. Terchloride of Gold.—This is formed by taking fine gold, one part; nitro-hydrochloric acid (two parts muriatic acid and one part nitric acid), three parts. These are placed in a glass flask, or porcelain capsule, when vigorous chemical action takes place, with evolution of red fumes; when these fumes cease to appear (a portion of the gold being still undissolved) this indicates that the acid has taken up as much gold as it is capable of doing. The clear liquid, which is chloride of gold, should then be poured into a porcelain capsule, or dish, and gently evaporated over a sand-bath; a small quantity of nitro-hydrochloric acid is then added to the undissolved gold, which in time will disappear, when the solution may be added to the former, and after further evaporation the vessel is set aside to cool, when orange-red crystals will form at the bottom and sides of the vessel. The liquid portion is then poured off and the crystals carefully drained and dried. Chloride of gold is soluble in water, alcohol, and ether, forming a deep yellow solution. A piece of steel dipped in the solution instantly becomes covered with metallic gold. This preparation has been frequently employed in medicine.

Cyanide of Gold.—A solution of pure cyanide of potassium is added to a solution of chloride of gold, so long as a precipitate is formed, carefully avoiding excess, which would dissolve the precipitate. After repeated washings with distilled water, and drying, the cyanide of gold is ready for use; it is employed in medicine.

The double Cyanide of Gold employed in electro-gilding is formed either by adding an excess of cyanide solution to the

precipitate formed in the last operation, or by dissolving the washed precipitate in a solution of cyanide of potassium.

Ammoniuret Gold. Fulminating Gold.—This is prepared by adding *liquid ammonia* to a solution of chloride of gold, so long as a reddish-yellow precipitate forms. This substance—which is *fulminating gold*—is then to be collected on a filter and washed; it must be dried over a hot-water bath *with great caution*, otherwise it will explode with great violence. We need scarcely say that amateur experimentalists should not venture on an acquaintance with this treacherous compound.

Grain Gold.—This attractive condition of gold—so often displayed in our refiners' windows—is prepared as follows: Gold of cupellation, one part; silver three parts. These are melted together in a crucible, and the molten alloy is then poured in a small stream of water, or *granulated*, as it is termed. The silver is afterwards dissolved out by digesting the metallic grains in boiling nitric acid. The grains are next washed repeatedly in water, after which they are dried, and *heated to redness* in a crucible or cupel, and when cold they assume the characteristic lustre of fine gold.

After digestion in nitric acid, by which the silver becomes removed from the alloy, the grains are exceedingly porous and soft, and when subjected to a red heat they contract considerably—in fact, to about one-fourth their size when alloyed.

Oxides of Gold.—Protoxide of gold is formed when *liquor of potassa* is poured on the protochloride of gold. It is a green powder, slightly soluble in liquor of potassa, and the solution decomposes spontaneously into metallic gold and teroxide of gold.

Teroxide of Gold is formed by mixing calcined magnesia, four parts; terchloride of gold one part; and water forty parts. The mixture is boiled, and the precipitate first washed with

water, then with dilute nitric acid, and lastly again with water.

Sulphuret of Gold.—To a solution of terchloride of gold, add, gradually, *sulphide of ammonium.* A dark brown precipitate is formed, which is readily soluble in cyanide of potassium, forming an excellent solution for electro-gilding (which see).

Purple of Cassius.—This compound was discovered in 1683, by Cassius, of Leyden. When *protochloride of tin* is added to a dilute solution of chloride of gold, an instant change of colour takes place, to a dirty purplish-brown. If a piece of tin-foil be immersed in a solution of the chloride, the same purple powder is presently thrown down upon it. It is also found when an alloy of 150 parts of silver, 35 of tin, and 20 parts of gold is digested in nitric acid; nitrate of silver is found in solution, and the purple powder remains. According to Graham, the finest-coloured precipitate is obtained when protochloride of tin is added to a solution of perchloride of iron, till the liquid has a shade of green, and adding this liquid, drop by drop, to a solution of perchloride of gold. After twenty-four hours, a brown powder is deposited, which is slightly transparent, and purple-red by transmitted light; when dried and rubbed to powder it is of a deep blue colour. Purple of Cassius is used in enamel and porcelain painting, and also for tinting glass a fine red colour; it retains its colour at a high red heat.

Phosphuret of Gold is obtained, according to E. Davy, by heating gold-leaf with phosphorus in a tube deprived of air. It is a grey substance of a metallic lustre.

Powdered Gold.—*Gold-Bronze.*—There are several methods of producing this elegant preparation of gold, but the simplest plan is to rub up a few leaves of gold with a little honey, with a pestle and mortar, or with a *muller* upon a marble slab, in the same way that paints are *ground.* After the leaf-gold and

honey have been sufficiently rubbed, a little hot water is added, which, dissolving the honey, allows the gold-bronze to deposit. The washings should be repeated several times, and the powder then collected and dried, when it may be put into a bottle until required for use. If a little of the powder be worked up with gum-water, it may be painted over the interior of a clean mussel shell or porcelain dish, for use in "illuminating" or for other artistic purposes. Another method of forming the gold powder is to triturate gold leaf with ten or twelve times its weight of sulphate of potash, in crystals, until all the gold leaf is thoroughly reduced to powder. The mixture is then heated with *boiling* water, to dissolve the potash, and after frequent washings the powder is carefully drained and dried.

Amalgam of Gold is formed by melting gold in a crucible, and then adding quicksilver. The amalgam is afterwards squeezed in a wash-leather bag to remove excess of mercury.

CHAPTER XII.

Imitation Gold—Abyssinian Gold—Dutch Gold—Mannheim Gold—Prince's Metal—Similor—Tombac—Mosaic Gold —Or-moulu—Factitious Gold.

Imitation Gold.—Abyssinian Gold, &c.—The reader will doubtless have noticed, during the past few years, that in certain shop windows have been exposed for sale a class of jewellery of admirable manufacture, and presenting all the appearance of genuine gold, bearing the respective titles, Californian, Oroide, Abyssinian Gold, &c. On looking at the articles to which the latter title is given, and the workmanship of which is even superior to that of many articles of so-called "gold" jewellery,

one cannot but be struck by the very close resemblance they bear to "coloured gold" work of superior quality. For the purposes of the present chapter, we recently paid a visit to the establishment of Messrs. L. and A. Pike, in Ely Place, Holborn, the manufacturers of Abyssinian gold jewellery, and having been courteously permitted to inspect the very interesting specimens in their show rooms, we may conscientiously give these gentlemen credit for a very chaste and useful manufacture. The imitation is perfect, and quite unlike the coarse and vulgar "Brummagem" jewellery so profusely exposed for sale some thirty years ago.

Many years since, while engaged in a series of experiments in connection with the alloys of copper and zinc, in varying proportions, we obtained several results in the *colour* of the alloy which so closely resembled that of fine gold as to be quite startling; such results, however, were purely accidental, and could not be reduced to a certainty. We have also obtained the same rich gold-coloured brass by electro-deposition, but in this case also there was the same uncertainty, though in a more marked degree, for the lightest increase or diminution of the electric current caused an instant change in the colour of the deposit. These facts, however, show that there is a certain combination of zinc and copper which, if it can be hit upon exactly, will produce an alloy of a pure gold colour. It is stated that the following will produce a good gold-coloured alloy:—

Pure copper, 100 parts; zinc, 17 parts; magnesia, 6 parts; sal ammoniac, 3·60 parts; quicklime, 1·80 parts, and tartar, 9 parts. The copper is first melted in a crucible, the magnesia, sal ammoniac, and tartar then added, one by one, gradually, each in a powdered state. The whole is then well-stirred for about half-an-hour, when the zinc, in very small grains, is introduced, and the stirring continued until the fusion is complete; the

crucible is then covered and the heat kept up for about 35 minutes, when it is uncovered, and the alloy poured into a mould. The alloy is very fusible and malleable, and will receive a brilliant polish.

Dutch Gold, Mannheim Gold, Prince's Metal, Similor, Tombac, &c.—Under these names various imitations of gold have been produced. According to some authorities the composition of Mannheim gold is copper, 85 parts; zinc, 15 parts; or copper 75, and zinc 25 parts. At the famous works of Hegermühl, near Potsdam, the proportions are said to be copper 11, and zinc 2 parts. This alloy produces a metal which is afterwards rolled into sheets, for the purpose of making *Dutch leaf gold.* It has a deep rich gold colour, and is so extremely malleable that it may be beaten into leaves not exceeding $\frac{1}{52900}$th of an inch in thickness. Dutch gold leaf is much used as a substitute for real gold leaf for "gilding" cheap picture frames and for other ornamental purposes.

Mosaic Gold. Or-moulu.—The composition of this alloy of copper and zinc, for which a patent was obtained in the year 1825, is as follows:—Equal quantities of copper and zinc are to be melted at the lowest temperature at which copper will fuse, and are to be stirred together so as to ensure a perfect admixture of the metals; a further quantity of zinc is added in small portions, until the alloy assumes the required colour. This alloy contains from 52 to 55 per cent. of zinc.

Factitious Gold.—An alloy which will resist the action of nitric acid is formed by fusing copper, 16 parts; platinum, 7 parts; and zinc, 1 part. It resembles 16-carat gold in colour. It is probable some such alloy was employed in manufacturing the "Mystery Gold" sovereigns lately introduced to the public.

INTERESTING NOTES ON GOLD.

In 1848, Californian gold began to come forward; and in 1851 the Australian fields were opened. Between 1849 and 1875 the gold production of the world has been estimated at six hundred and sixteen millions sterling, so that in twenty-seven years the stock of gold was more than doubled. The average annual supply previous to 1848 was eight millions sterling; in 1852 the production was thirty-six and a half millions sterling. An Australian authority estimates the yield of the colonies from 1851 to 1881 as two hundred and seventy-seven millions sterling.

Ashantee War Indemnity.—In a vault in which bullion is kept at the Bank of England, there is a glass case containing the remnants of the Ashantee war indemnity, consisting of various trinkets and other ornaments in gold, some of which appear to have been hammered into shape, others apparently cast, while there are several specimens of filigree work. A curious ornament, somewhat resembling three prawns in a row, has probably been produced by casting from a model. Many of these interesting objects give evidence of a more intimate acquaintance with art than would have been expected from the savage source from which they came.

Among the interesting exhibits of the Patten Makers' Company in "Old London" at the Health Exhibition, 1884, might

be seen the boots, embroidered and iron shod, worn by Henry VIII., at the Field of the Cloth of Gold.

Some beautiful specimens of gold jewellery were discovered in the Island of Cyprus, some years ago, supposed to have been made at least eighteen hundred years before the Christian Era. They were purchased by Messrs. Tiffany, of New York, who skilfully reproduced them and exhibited them at the Paris Exhibition of 1878.

The Sydney branch of the Royal Mint was opened for the receipt and coinage of gold on May 14th, 1855. It is under the immediate control of the Lords Commissioners of Her Majesty's Treasury. The coins struck there are sovereigns and half-sovereigns. They are a legal tender within the United Kingdom, and are identical in every respect with those issued from the Royal Mint in London, with the exception of a small "s," which is added as a distinguishing mark. New silver and bronze coins from the London Mint are supplied to the Sydney branch for distribution in the colony. From the opening of the Mint in 1855 to the end of 1882 the receipts of gold coinage amounted to 13,259,363oz., value £50,590,326, while the issues were £48,161,000 in coin and £2,417,202 in bullion, making a total of £50,578,202. The revenue derived from the Mint charges, and other sources, has been £455,753, and the total expenditure £424,223.

Towards the close of the seventeenth century "clipping and coining" had developed to a very great degree in England, and incarceration and hanging were frequent for these offences. In 1692, it is recorded, there were 300 coiners and clippers

dispersed in the City. So bold were the coiners that they made their counterfeit money even in the gaol of Newgate. To show their skill, they struck a medal of Newgate, which is still to be found in English collections.

It is stated that the Iron Crown of Lombardy consisted of a broad fillet of gold, within which runs a thin circlet or hoop of iron, formed of one of the nails of the Holy Cross beaten out. Many kings and emperors have been crowned with it, including Charles V. and Napoleon Buonaparte. It is now preserved in the Belvedere Museum, Vienna, though until 1859 it was kept in the Chapel of the Holy Nail at Monza, Italy. It is said to have been brought from Palestine by the Empress Helena.

Sweating Gold Coins.—About forty years ago, it was discovered that sovereigns were being reduced in weight by some artificial means in a remarkable degree, while the coins themselves exhibited no appearance of having been tampered with. It was understood that the method adopted by the "sweaters" was to shake the coins in a bag containing sand, from which the gold was afterwards extracted by mercury. The "light sovereign" scare occurred at this time, and while bankers *counted* their gold when giving change for notes or cheques, they *weighed* the gold when receiving it. About this time, the author, then a lad, on presenting a cheque at his brother's banker's, in answer to the usual question, "How will you have it?" inadvertently replied, "In gold." The cash was required to take up a bill, and when tendering the money at the bank where the draft was payable, the gold was "weighed in the balance—and found wanting!" About a dozen of the sovereigns

were *light weight*, and he had to sell them to Messrs. Bult, in Cheapside, for their value as *old gold* at a reduction of about eightpence upon each coin!

Respecting what is termed "the life of a coin," it is reckoned that a sovereign loses in weight in eighteen years, while a half-sovereign loses weight in ten years. Mr. Roberts says: "The life of a coin, after it leaves the Mint, may now be traced, and it will be seen that the conditions of its existence are far less severe in modern than they were in ancient times. The actual wear to which coins are subjected may, no doubt, be rougher at the present day than in the past; but, on the other hand, they are not subject, to anything like the same extent, to ill-treatment from enemies in the shape of clippers and sweaters."

Gold coins have been fraudulently reduced in weight by immersion in *aqua regia*, and also by aid of a galvanic battery and a solution of cyanide of potassium. "Removal of metal by drilling holes," says Professor Roberts, "and filling them up with base metal, has sometimes been resorted to, and the Mint Museum contains interesting examples of American coins which have been sawn so as to leave two thin flat discs, which have subsequently been soldered over a disc of base metal, the precious inside of the coin having been removed. It has been proposed to make the American gold double-eagle dish-shaped, in order to render the centre so thin as to prevent this method of falsification. In mediæval times, tampering with the coin caused the gravest anxiety, and was punished with dreadful severity."

The Coinage Act of 1870 fixes the "remedy" for each individual piece, and not, as formerly, on the pound weight of coin,* the object of which is to prevent the "culling" of the heavy pieces, which would be very profitable if many of the coins happened to be over weight. Heavy pieces thus selected or "culled" might either be exported or used in the arts, which the history of coinage has proved to have been formerly the practice. According to Rudling, a notable case occurred in 1637, when the Attorney-General charged several persons before the Star Chamber with "culling out the weightiest coins, and with melting down his Majesty's moneys into bullion;" and, on examination, it appeared "that between the years 1626-1631, one Timothy Eman culled £500,000 a-year, which yielded £7000 or £8000 of heavy moneys yearly, and in five years he melted down £15,000, his profit amounting to £100."

Lost Gold.—In a letter to *The Standard* newspaper, of November 11th, 1865, headed "Lost Gold," the author called attention to the fact that much of the gold used in the arts was practically lost beyond man's power to recover it. Thus, the gold employed in gilding picture and mirror frames, in interior and exterior decorations, in electro-gilding and water-gilding, in china and porcelain painting, in bookbinding and the letter-gilding on shop facias, &c., may be considerend as practically *lost*. The same may be said of all powdered gold (gold-bronze), or leaf-gold, when once they have been used; while the gold used by photographers for *toning* their pictures—a comparatively small amount—must also be regarded as *lost gold*. It must be borne

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* The standard weight of coin, as prescribed by an Act of George III., was as follows:—20 lbs. of standard gold must contain 984 sovereigns and 1 ten-shilling piece.

in mind that this waste of gold, as we may term it, is going on in every civilized part of the earth.

At the Bank of England, automatic weighing machines of remarkable delicacy are employed for weighing sovereigns and half-sovereigns. The coins are introduced into an inclined metallic slide, one above another, and by an automatic arrangement of the machine the light coins pass out at one side of the lower end of the slide, while those of full weight pass out at the right side, and are received in a separate pocket beneath.

Mr. Gee, in his "Goldsmith's Handbook," says:—"As far as we have been enabled to ascertain by reference, gold is mentioned in the Bible in all upwards of three hundred times, in connection with various things, with the manipulation of which the old Jewish patriarchs must have been tolerably conversant, for we read of jewels, crowns, bowls, knops, bars, pillars, hooks, flowers, rings, chains, bells, plates, tablets, ouches, and talents of gold; also cherubims, candlesticks, mercy-seats, ephods, breast-plates and calves, all of which were of gold; there were besides settings of gold, tables covered with gold, houses embellished with gold, while the throne itself is said to have been overlaid with pure gold."

MINT VALUE OF GOLD.—Taking twenty-four as the unit of fine gold, the following table will show the relative value per troy ounce of the alloys most commonly used for manufacturing purposes, at the Mint prices of purchase:—

24-carats (fine, or pure gold) . . .	£4	5	0

22-carats	(used for current coin and wedding rings)	£3	17	11
20 „	(for best cast rings in which soft stones, as emeralds, opals, &c. are set)	3	10	10
18 „	(used for watch cases, mourning rings, &c.)	3	3	9
16 „	(used for chains, bracelets, &c.; commonly called "fine gold" in the shops)	2	16	8
14 „	(used for spectacle frames, gold springs, stems of pins, &c.)	2	9	7
12 „	(commonly called "jewellers' gold")	2	2	6
9 „	(used for cheap jewellery in Birmingham)	1	11	10½

In purchasing one ounce of fine gold from the refiners, the cost will be £4. 6*s*, the extra charge being for the expenses of refining; large quantities, say from above ten ounces, will cost from 3*d* to 6*d* per ounce over and above the Mint value.

Wedding-ring makers have to pay a duty upon their manufacture of 17*s* per ounce, one-sixteenth being remitted for loss in finishing, because it is compulsory that this quality should, when made into wedding-rings, be Hall-marked, and this has to be done when the articles are in an unfinished state; therefore, for every six ounces you pay for five, and so on. For this reason it is usual to melt down the coin of the realm, and for more purposes than one it is an advantage to wedding-ring manufacturers to do so, for they can depend upon the quality, and also effect a saving of from 4*d* to 5*d* per ounce.—*Gee.* Watch-cases, which are also Hall-marked, are manufactured duty free.
